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INTEGRATING TECHNOLOGY TO REDUCE FRATRICIDE

Larry Doton

The high incidence of fratricide during the Gulf War requires materiel developers to anticipate and compensate for the consequences of partially or completely non-integrated technology. Solutions include thorough risk assessments for all systems, combat identification capability equal to the range of the weapons employed, and service integration of IFF technology.

This paper will analyze the application of technology in our modern warfighting systems, evaluating the potential adverse impacts of applying mismatched, non-integrated, or incomplete technology to a requirement. It will substantiate the criticality of thorough requirements analysis prior to implementation of technology in major weapons systems. The paper will show that the high fratricide rates in the Gulf War were due to incomplete and non-integrated applications of technology, resulting in a 'blind' spot for the lethal warfighting systems. The paper will discuss fixes made during the Gulf War and current initiatives to solve the problem. Finally, it will offer recommendations to minimize the incidence of fratricide in future conflicts.

Given the lethality of our warfighting systems, it is imperative that the application of technology be carefully analyzed and that the consequences of inappropriate or incomplete application be averted. Columnist and retired Army colonel Harry Summers recently addressed an argument made by Walter Lippmann, writing in December, 1941, that air and sea power would prevail in World War II with ground forces playing only a minor role. Wrote Summers:

> Lippman [did] not understand the dynamics of the Army where man is still dominant and the machine merely a tool. Technology must serve the soldier, not vice versa (Summers, 1995).

Summers is right. Requirements should drive the technology, not vice versa. We must critically evaluate the importance of the man-machine interface to minimize the possibility of fratricide.

The Gulf War verified the importance of superior knowledge on the battlefield. This control of knowledge, and its denial to the enemy, proved to be an indispensable factor. As Alan Campen noted in the Introduction to The First Information War, allied forces could see, hear, and talk all through the war. After a few hours, the enemy could not. Campen also discusses the ability of information warfare technology to support a leaner and cheaper force while continuing to effectively support the nation's goals and objectives. Victory in any future conflict will hinge on our ability to win the information war. A vital part of winning the information war is the prevention and minimization of fratricide.

What is Fratricide?

To understand the lack of serious attention given this problem prior to the Gulf War, it is important to grasp how restrictive the official definition of fratricide is. The Center for Army Lessons Learned, quoting from the U.S. Army Training and Doctrine Command's Fratricide Action Plan, defines fratricide as:

> The employment of friendly weapons and munitions with the intent to kill the enemy or destroy his equipment or facilities, which results in unforeseen and unintentional death or injury to friendly personnel (Department of the Army, 1992).

In a recently published study on fratricide, Army Col. Kenneth Steinweg, a physician, argues that, "This restrictive definition precludes accidental weapon explosions and misfires, training accidents, casualties from unexploded ordnance, or self wounding of any kind. This artificially reduces the true fratricide percentage rate" (Steinweg, 1994).

In his 1982 paper on the same subject, Army Lt.Col. Charles Shrader coined the term amicicide. He derived this from the legitimate combination of the Latin noun amicus (friend) with the common latinate suffix for killing (-cide) (Shrader, 1982). The term *fratricide* was at that time applied most often to casualties inflicted by artillery projectiles. This limited definition artificially lowered true fratricide rates.

History of Fratricide in War

A brief history of fratricide since the 18th century illustrates the evolution of problems in positive combat identification. This history documents that combat identification remains a critical problem, particularly with our techno-

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logical capability to engage targets at previously unfathomable ranges. These ranges go beyond the capability to visually distinguish friend from foe.

In 1758, during the French and Indian War, the commander of a British detachment and Col. George Washington, then a colonial officer of the British Army, mistakenly identified each others' forces as French. In his papers, Washington reported that between 13 and 40 British soldiers died at the hands of their own forces during the ensuing engagement (Abbot, 1988). Uniforms at that time identified alliance. Due to the 'fog of war,' that means of identification proved to be ineffective.

Of the five million French casualties in World War I, artillery caused two-thirds, regardless of friend or foe. French General Alexandre Percin believed that French artillery fire caused one million, or 20 percent of French casualties (Hawkins, 1994). During the breakout from Normandy in the Second World War, British aircraft inadvertently bombed the 30th Division for over two days, killing, among others, American Lt.Gen. Leslie J. McNair. At the Battle of the Bulge, the First Infantry Division became the target of heavy 'friendly' bombing. In St. Lo, over 750 casualties occurred as a result of U.S. bombers attacking American ground forces.

Meanwhile, in the Pacific theater, an allied destroyer depth-charged and sank an allied submarine; likewise, in the Caribbean, friendly fire sank the American submarine USS Dorado.

The Korean War saw similar occurrences: A napalm bomb dropped by an American plane incinerated nearly an entire U.S. Marine platoon. And combat identification problems continued in Vietnam. In his study of fratricide, Shrader referenced many Vietnam friendly fire occurrences. Among them was a terrible artillery incident. It happened in 1967 when a gun crew cut an incorrect powder charge. The 'long' round killed one and wounded 37 U.S. soldiers. Compounding the tragedy, the victim's unit initiated extremely accurate counterbattery fire, resulting in an additional 53 casualties. The entire incident occurred in the short span of 23 minutes (Shrader, 1982, p. 21).

In a recent keynote address on fratricide, the Assistant Secretary of Defense for Command, Control, Communications, and Intelligence reported that fratricide caused over 30 percent of all aircraft losses during the 1973 Israeli-Egyptian War (Paige, 1994). Incidents of fratricide also occurred in Grenada and Panama. In Grenada, four Navy A-7 aircraft strafed a U.S. Army command post, inflicting 17 American casualties. Similarly, in Panama, friendly fire incidents accounted for three of 23 killed and between 16 and 37 of 310 wounded, as reported by Defense Department spokesman Pete Williams during the June 19, 1990 daily DoD press briefing (Department of Defense, 1990).

As this brief history documents, fratricide is not a new phenomenon, but a recurring and deadly problem in combat identification. Despite the evolution of high technology systems for warfighting, 'blind' spots exist and fratricide continues to occur.

Operation Desert Storm: The First High Technology War

Ground combat identification again emerged as the core issue related to fratricide during the Gulf War. In an article published in the Journal of Electronic Defense, Vito DeMonte succinctly described the friendly fire statistics of Operation Desert Storm.

> Never before have we fought such a short war, in such a confusing environment, with such a great percentage of deaths due to friendly fire (Demonte, 1992).

Friendly fire killed 35 Americans and wounded 72 during the Gulf War. In a special column in The Washington Post, Robert MacKay reported that of the 35 Americans who died, 24 died as a result of ground-to-ground fire, and 11 succumbed to fire from U.S. aircraft (MacKay, 1993). The Office of Technology Assessment (OTA) determined that the official friendly fire casualty rate for Desert Storm was 24 percent (Office of Technology Assessment, 1993). This figure did not include the British soldiers killed by aircraft bombing, nor did it include engineer and medical personnel, who were casualties of unexploded ordnance. As documented in his paper on unexploded ordnance, Lt.Col. Gary Wright stated that 94 separate incidents involving unexploded ordnance occurred during Operation Desert Storm. These incidents equated to 104 woundings and 30 deaths, 10 percent of total casualties in the operation (Wright, 1993). Rick Atkinson of The Washington Post reported that despite the hundreds of fixed and rotary-winged aircraft from more than a dozen allied nations, none of the Gulf War fratricide cases involved air-to-air fratricide (Atkinson, 1994).

...fratricide rates during conflicts of the 20th century equaled at least five to eight times the generally accepted two percent figure.

Understatement of Fratricide Rates

The high incidence of fratricide in the Gulf War brought new and heightened attention to this historically troubling problem. The Office of Technology Assessment agreed (with Steinweg) that past rates of fratricide were systematically and substantially underestimated (Office of Technology Assessment, 1995, p. 1). Shrader's 1992 study, though "primarily historical, narrative, and highly selective," concluded that "casualties attributable to friendly fire in modern war constitute a statistically insignificant portion of total casualties (perhaps less than two percent)" (Shrader, 1982, p. vii). Because of the dearth of published documents on this subject, Shrader's assessment had become the de facto standard. In subsequent published articles, Shrader acknowledged that actual fratricide rates are considerably higher than two percent (Shrader, 1992). In a 1993 interview, Shrader further acknowledged that higher rates are prevalent. He stated that "It just seemed to be the number that I kept coming up with, based on the materials that I had to

work with, which were pretty limited" (MacKay, 1993, p. A-4).

In a 1994 paper on the subject, Steinweg substantiated his thesis that fratricide rates during conflicts of the 20th century equaled at least five to eight times the generally accepted two percent figure (Steinweg, 1994, p. 1). Steinweg's study examined historical evidence of the 20th century, experiences at the National Training Centers, and the application of technology. Because the casualty reporting system failed (and continues to fail) to accurately document fratricide, Steinweg also used medical documents in substantiating his thesis. Steinweg concluded that "Fratricide rates have been and are conservatively 10-15 percent of our casualties, not two percent" (Steinweg, 1994, p. 29).

In 1992 another Army physician, Col. David M. Sa'adah, presented a paper to the 31st U.S. Army Operations Research Symposium at Fort Lee, Virginia. Sa'adah compared data from five casualty surveys (three in the Pacific during World War II and two from the Vietnam War) with Desert Storm data. He concluded that all weapons available on the battlefield are potential contributors to friendly fire incidents. Further, he asserted that movement from defensive to offensive operations resulted in increased fratricide rates, sometimes by a factor of two (Sa'adah, 1992).

Operation Desert Storm was the first major conflict in which America's fighting forces used the high technology weapons systems designed and built during the Reagan Administration. It proved to be a major test of the billions of dollars invested. The One Hundred Hour War did liberate Kuwait and severely defeated Saddam Hussein's forces.

In an article published shortly after the Gulf War, John D. Morrocco, a writer for Aviation Week & Space Technology, lauded the performance of the high technology systems used during the conflict. He also postulated that the Department of Defense would continue to press for high-leverage advanced technology systems.

> Operation Desert Storm [has] validated the U.S. military's emphasis on quality versus quantity in weapon systems and provided a tremendous boost to the credibility of high-technology programs now in development (Morrocco, 1991).

Yet, the fratricide rate for the Gulf War rivaled that of all conflicts in this century.

In previous conflicts, artillery inflicted the highest percentage of fratricide deaths. The Office of Technology Assessment reported that the sole artillery fratricide incident in Desert Storm occurred on February 26, 1991, when one soldier died from injuries inflicted by the premature burst of an artillery round (Office of Technology Assessment, 1993, p. 27). That single incident accounted for less than two percent of the fratricide casualties in the conflict. Steinweg and Sa'adah's research sub-

> **"Reducing fratricide is 'right near the top, if not right at the top' of the list of critical areas that the Army is currently exploring."**

stantiates previous fratricide figures as routinely in the 15-20 percent range, vice the previously quoted Shrader rate of two percent.

Desert Storm data revealed a new paradigm. At the 1994 Combat Identification System Conference, Col. Sa'adah reported that the M1A1 Abrams tank inflicted 71 percent of fratricide casualties during the war (Sa'adah, 1994). Journal of Electronic Defense writer Zachary Lum further substantiated Sa'adah's findings.

> The Abrams M1A1 was the worst offender in the Gulf, responsible for 85 percent of the fratricide casualties. (The U.S. lost 10 tanks in the war, seven to fratricide; of 28 Bradley Fighting Vehicles destroyed, 22-23 were victims of fratricide.) (Lum, 1993).

Sa'adah's research documented the redundant lethality of what he termed weapons 'platforms.'

> The fratricide agent is not the specific weapon, but the platform where the firing decision resides... The main gun is accurate and lethal to the target vehicle, but it was the follow-on with the lesser armament that created the majority of casualties (Sa'adah, 1994, p. 8).

The variation in calculated fratricide rates highlights the difficulty in definition (Shrader and Steinweg), as well as the non-standard application of calculation methodologies. Nevertheless, figures clearly substantiate the significance of the problem and fall in line with Steinweg and Sa'adah's finding.

As a result of the Desert Storm figures, fratricide became a topic of increased attention. The Department of Defense and the services formed Fratricide Task Forces. In an August, 1993 article in the Journal of Electronic Defense, Col. David O. Bird, Team Chief of the Army Materiel Command's Fratricide Task Force, spoke of the high priority in coming to the quickest possible total solution for fratricide reduction. "Reducing fratricide is 'right near the top, if not right at the top' of the list of critical areas that the Army is currently exploring" (Lum, 1993, p.48). Retired Navy Commander George Cornelius reported in a Signal magazine article that the Gulf War experience, because of air supremacy, rendered air-to-air and ground-to-air identification problems nearly irrelevant. However, the problem of air-to-ground and ground-to-ground encounters revealed serious shortcomings in combat identification capabilities (Cornelius, 1994).

The Department of Defense and the Clinton Administration have indicated that they recognize that the probability of fratricide cannot be eliminated. Their reasonable goal is the reduction of fratricide. Secretary of Defense William Perry charged the services to rapidly develop and field, as a high priority, an integrated, enhanced identification capability to reduce the risk of fratricide to armor, aircraft, and ships. He further declared that the Army should reduce the possibility of fratricide through enhancement of situational awareness technology (Paige, 1994, p.2). Situational awareness is officially defined by the U.S. Army Combined Arms

Command as:

> The real-time accurate knowledge of one's own location (and orientation), as well as the locations of friendly, enemy, neutrals, and noncombatants. This includes awareness of the METT-T conditions that impact the operation (Department of the Army, 1992).

Similarly, Maj.Gen. Wesley K. Clark, then a deputy chief of staff at the U.S. Army Training and Doctrine Command, was quoted as saying "So we've got to focus on the minimization... recognize that we will never be able to prevent all instances of fratricide" (Gellman and Lancaster, 1991).

The Office of Technology Assessment also recognized that reduction of fratricide is a correct and reasonable approach.

> Reducing fratricide is desirable and feasible, but eliminating it is not. Although programs to reduce fratricide are certainly needed, setting a goal of eliminating it is unrealistic and probably counterproductive (Office of Technology Assessment, 1993, p. 2).

Believing that the application of technology alone will solve the problem is fallacious and foolhardy. As Cornelius stated in an article published by the U.S. Naval Institute Proceedings, "Electrons, however marvelous, can never relieve humans of the awful responsibility of the final, lethal decision to fire" (Cornelius, 1993).

Advances in technology, ironically enough, can exacerbate, rather than improve some situations. They are but one piece of the pie. Emmett Paige, Jr., Assistant Secretary of Defense for Command, Control, Communications, and Intelligence, recently substantiated this point in a keynote address to the 1994 DoD Joint Service Combat Identification Systems Conference.

> Unless we have reliable means of positively identifying foes at long range, the technological advantage we have achieved in our weapon systems, at great expense, will be partly negated (Paige, 1994, p. 3).

Beyond Visual Range (BVR) technology permits detection of potential targets at previously unattainable ranges. As the term implies, the eye cannot detect, let alone identify a target as either friend or foe. BVR technology can detect targets significantly smaller than a pixel on our sensors, thereby precluding positive identification. Unfortunately, the Desert Storm record of fratricide proved a downside to these technological advancements. DeMonte highlights the major reason. "Engagement ranges became so extended that differentiation between friend or enemy leapt beyond the capability of the 'sensor-aided eyeball'" (DeMonte, 1992, p. 35).

...the fratricide experienced during the Gulf War was a legacy of previous weapons acquisition policies.

NON-INTEGRATED APPLICATION OF TECHNOLOGY

To a large degree, the fratricide experienced during the Gulf War was a legacy of previous weapons acquisition policies. Planners and designers of high technology warfighting systems, such as the Bradley Fighting Vehicle, the Abram's tank, the Multiple Launched Rocket System (MLRS), improved conventional munitions, and scatterable mines failed to account for collateral or unforeseen impacts. Employment of BVR technology without evaluating all consequences, resulted in a 'blind' spot in the positive identification of ground combat vehicles.

A review of official documents reveals recognition of the need to improve combat identification. However, prior to the Desert Storm experience with fratricide, little substantive progress occurred in reducing its incidence. The commander of the Combat Developments Command, in a November, 1967 letter to the Army Chief of Staff (Department of the Army, 1967), observed that soldiers must be conditioned to distinguish between friend and foe. He recommended a study to analyze modification of training firing ranges to condition trainees to make distinctions among targets prior to firing.

..."failure to consider effects of unexploded submunitions increased the potential for friendly deaths."

The November, 1967 letter also reported that improvements in techniques for visual recognition of friendly personnel and procedures for battlefield identification appeared necessary.

Review of applicable Cost and Operational Effectiveness Analyses (COEA) for combat vehicles in the late 1970's (i.e., for the systems later used in Desert Storm) revealed that combat identification was not a system requirement. In the area of survivability, COEA data consistently concentrated on the areas of large and small caliber direct fire weapons; indirect fire; mines; nuclear, biological, and chemical weapons; and air attack (Department of the Army, 1978). In no single COEA was there a reference to combat identification or identification friend-or-foe (IFF) technology (Department of the Army, 1963). Built-in features such as fire suppression, blow-out panels, hardened armor, and protective linings served to increase survivability. These measures proved effective in minimizing the impacts of friendly fire during the Gulf War. As it turned out, the incorporation of IFF would have been a more effective survivability factor.

In a February, 1974 letter following the 1973 Arab-Israeli conflict and the Israeli's difficulty in identifying friendly from enemy tanks, the Assistant Secretary of the Army for Research and Development acknowledged that there was not a battlefield IFF system for use with tanks (Department of the Army, 1974). He directed the Army staff and the U.S. Army Training and Doctrine Command to determine the Army's need for a battlefield IFF system for tanks.

In June, 1982, J.R. Sculley, the Assistant Secretary of the Army for Research, Development, and Acquisition, in a memorandum for the Under Secretary of Defense (Research and En-

gineering), concluded that there was no requirement for an electronic question and answer system for ground combat vehicles (Department of the Army, 1982). The Assistant Secretary based his recommendation on the results of a Battlefield Identification Friend-or-Foe (BIFF) study (Science Applications, 1979).

The Rand Corporation conducted a study on ground-to-ground fratricide at the National Training Center in 1986. In the study entitled *Applying the National Training Center Experience - Incidence of Ground-to-Ground Fratricide*, Martin Goldsmith provided several conclusions. His data revealed that half of the recorded fratricides were preventable if the shooter had proper knowledge of the location of friendly units. Further, he found that one third of the fratricides were preventable if tank gunners had knowledge of the location of individual friendly vehicles. Finally, Goldsmith found that 17 percent of fratricides were also preventable with the implementation of IFF devices on combat vehicles.

In the case of the MLRS, a 'blind' spot in doctrine emerged during the Gulf War. In his paper on the problem of unexploded ordnance on the battlefield, Lt.Col. Gary Wright calculated that more than 1.5 million unexploded munitions (UXO) remain on the Gulf War battlefield. Wright further documented that vast amounts of submunitions targeted beyond the Forward Support Coordination Line caused maneuver problems as ground forces thundered into Iraq. Wright documented that "Many units found themselves in areas that were saturated with submunitions" (Wright, 1993, p. 17). Further, Wright stated that "The transfer or sharing of UXO information is not currently in our Joint or Service doctrine" (Wright, 1993).

Unfortunately, this is not a new phenomenon. It applies, as well, to minefield placement. In the November, 1967 letter previously cited, the commander of the U.S. Army Combat Developments Command noted the inadequate reporting and recording of friendly protective minefields. The commander reported that casualties in Vietnam occurred because units failed to record or retrieve minefields before moving. The report recommended renewed compliance with the published doctrine.

Project office technical management engineers and the Studies Branch Chief in the System Manager's Office for MLRS confirmed that:

> The battlefield safety of operating areas where submunitions had been delivered was not considered during the design and early production of the system (MLRS). They [the System's Manager's Office, Training and Doctrine Command] said the Army believed the weapon would most likely be used against the Soviet threat in Europe, where U.S. troops would probably be in a defensive position. Therefore, U.S. soldiers were not expected to occupy submunitions-contaminated areas (General Accounting Office, 1993).

The U.S. Army Training and Doctrine Command's System Manager for

Cannon acknowledged that the "failure to consider effects of unexploded submunitions increased the potential for friendly deaths" (General Accounting Office, 1993, p. 8).

Tank developers likewise failed to recognize the consequences of a non-integrated application of technology (i.e., IFF for ground combat vehicles). A senior Army officer who served over 29 years as a tank expert reported in an interview that the issue of tanks' vulnerability to fratricide was not a significant part of building a better tank. Further, he indicated that such technologies as transponder systems were excluded from tank designs for a number of reasons (Tyler, 1991). Cornelius' research indicates that Army planners routinely dismissed IFF technology. Arguments for rejection included maintenance complexity, better use of room used otherwise, and perceived dangers that emissions might reveal a unit's location (Cornelius, 1993, p. 89).

In the previously mentioned Gulf War friendly fire incident, an AH-64 Apache battalion commander, due to inadequate combat identification, mistakenly engaged a Bradley Fighting Vehicle, killing two persons and injuring four. This showed clearly that despite all of its high-tech gadgetry, the Apache and its human pilot cannot distinguish between friendly and enemy forces in adverse weather conditions obscuring visual identification and verification (Johnson and Solomon, 1991). Without some sort of transponder or IFF device, American and coalition ground combat vehicles could continue to be mistaken targets in future conflicts.

As previously documented, ground combat identification accounted for nearly all the incidents of fratricide in the Gulf War. Admittedly, however, combat identification is not a simple task. Rudolf Buser, director of the U.S. Army Communications and Electronics Command's (CECOM) Night Vision and Electro-Optics Directorate at Fort Belvoir, Virginia, succinctly delineated the complexities of combat identification.

> Combat identification is a complex problem involving tradeoffs in performance, covertness, cost, and other factors, and no single solution exists. The Army is pursuing a number of technical approaches to solve the problem (Morzenti, 1991).

The Desert Storm experience served as a wake-up call for those designing and developing future systems. In the future, combat and materiel developers must fully consider positive combat identification. The capability to positively identify ground combat vehicles must be equal to or greater than the engagement range. Technology must be integrated and matched to minimize the occurrence of fratricide.

Operation Desert Storm Quick Fixes

Following the first incidence of fratricide during the Gulf War at the battle of Kafja, a number of emergency efforts were made to prevent fratricide. These efforts recognized the combat identifi-

cation gap as it applied to ground combat vehicles. With a full-fledged ground war impending, the Department of Defense initiated a number of quick fixes. One of the devices was an infrared beacon, termed an Anti-Fratricide Identification Device (AFID). Procured in only 24 days by the Defense Advanced Research Projects Agency (DARPA), the infrared beacon used two high-powered infrared diodes to emit optical power. Because of air supremacy, there was little danger that Iraqi aircraft would use emissions from the devices to target coalition vehicles. The AFID employed a protective collar to prevent infrared energy from being seen by ground forces. Used in conjunction with Night Vision Goggles, the devices allowed coalition pilots to detect and identify the AFID emissions from as far away as 8-10 kilometers. Between inception and full-scale production, engineers made over 100 mechanical, electrical, and functional design changes in just four days. Though initially called AFID, it became known as the DARPA light, after the agency that procured it. The DARPA light had a 50-hour battery life. Each device shipped to the desert had two additional battery packs (Hughes, 1991).

Another infrared emitting device, designed by Army night vision engineer Henry 'Bud' Croley, did not have a shroud to preclude ground detection. This allowed Bradley and Abrams crews to see them, as opposed to limiting detection to fixed or rotary wing aircraft. The device was dubbed the 'Budd Light,' partially in deference to Croley and also as a reminder of the customs of the host nation.

The Army rushed over 120,000 square feet of thermal tape to the theater. This tape was used to 'mark' vehicles as friendly when acquired by heat seeking target acquisition sights. Because the coalition forces had no monopoly on infrared and night-vision sensors, there was concern that the thermal panels might serve as bull's eyes for Iraqi forces. In Desert Storm this did not happen.

The device was dubbed the 'Budd Light'...

The Army also ordered over 10,000 Small Lightweight Global Positioning Receivers to assist vehicles in determining their locations. Although only effective in daylight and with good visibility, the coalition forces also used a field expedient side marking technique. VS-17 panels marked ground vehicles on the top and inverted 'V's marked side panels on coalition vehicles, identifying them as friendly forces. Inverted 'V' symbols consisted of a variety of materials, including fluorescent placards, white luminous paint, black paint, and thermal tape. Overall, these measures proved to be marginally effective.

Initiatives Aimed at Resolution

The immediate and overwhelmingly positive efforts in fielding expedient remedies during the Gulf War were admirable. However, these efforts did not work well and failed to negate the impacts of bad weather, poor visibility, and night combat conditions. Cornelius summarized the impact in a U.S. Naval Institute Proceedings article.

> Cheap, simple measures to identify friendly armor have not worked well. Colored panels are invisible at night and at best seen only at close range; colored lights were better, but easily duplicated by the enemy (Cornelius, 1993, p. 90).

Because of the minimal positive impacts of quick fixes, efforts to return to the pursuit of IFF technology redoubled. Following the war, DoD established a Joint Combat Identification Management Office. The office coordinates the activities of the services. The U.S. Navy is the lead service in the area of cooperative airborne identification. The Navy's focus is on upgrading existing IFF systems for air-to-air and surface-to-air contacts. Under the auspices of the Program Executive Officer for Intelligence and Electronic Warfare, the U.S. Army Battlefield Combat Identification Systems Program Manager leads the largest effort. The U.S. Army Materiel Command and the Deputy Chief of Staff for Research, Development, and Acquisition provide materiel and hardware solutions. The U.S. Army Training and Doctrine Command is responsible for testing and evaluation (Starr, 1993).

The Army began installation of immediately available off-the-shelf navigational applications on the M1A1 tank, the M2/M3 Bradley Fighting Vehicles, and the 'Hummer' utility vehicle. These applications are an interim solution, pending investigation of alternative technologies. The devices add additional position/navigation (POS/NAV) and situational awareness capabilities. The receivers to be installed are the Small Lightweight Global Receiver (SLGR) and the Precision Lightweight Global Receiver (PLGR) (Starr, 1993).

The Combat Identification Project Management Office currently focuses on a near-term solution to the problem. Following tests at a fly-off competition at Fort Bliss, Texas in 1992, the Army selected millimeter wave (MMW) technology for further development. Competing against infrared laser beacons, retro-reflector lasers, and radio frequency (RF) based solutions, MMW technology was selected for further development because it is least affected by smoke or bad weather (Starr, 1993).

The Project Office faces many challenges, not the least of which is cost. The estimated cost for equipping a single division's worth of vehicles is currently estimated to be $250 million (Starr, 1993). The Assistant Secretary of Defense for Command, Control, Communications, and Intelligence, based on an assessment by the Joint Requirements Oversight Council (JROC), recommends near-term armor identification techniques on the order of $1,000 per application (Paige, 1994, p. 3). Additionally, the Project Office must ensure that MMW technology is compatible with U.S. Navy and U.S. Air Force combat identification plans (Starr, 1993, p. 961).

A less expensive alternative to spending $250 million per division is to equip approximately 1,500 vehicles. This would be sufficient to support a substantial contingency force. The Office of Technology Assessment estimates an outlay of about $100 million to outfit such a force with MMW technology

(Roos, 1993).

Many positive initiatives grew from the Desert Storm experience with fratricide. In April, 1993, the Army Deputy Chief of Staff for Operations and Plans published the Operational Requirements Document (ORD) for the Battlefield Combat Identification System (BCIS) (Department of the Army, 1993). The document mandated the need for a target identification system with ground-to-ground and air-to-ground capability. This ORD supported the April, 1992 U.S. Army Training and Doctrine Command Operational and Organizational (O&O) Plan for Army Combat Identification Systems, which itself required an effective and survivable combat identification system to preclude engagement of friendly forces and noncombatants. The O&O plan mandated the capability to positively engage targets out to the maximum effective range of the designated weapons system, with or without line of sight (LOS) technologies (Department of the Army, 1992).

The U.S. Army Training and Doctrine Command published TRADDOC Pamphlet 525-58, *U.S. Army Operations Concept for Combat Identification*, in August, 1993. The pamphlet provides the Army with a concept for combat identification which will increase combat effectiveness, prevent fratricide, and protect neutrals and noncombatants.

In December, 1993, the Vice Chairman of the Joint Chiefs of Staff directed that the Joint Requirements Oversight Council (JROC) screen all future Operational Requirements Documents (ORD) to ensure that no new combat systems proceed to a Milestone I decision unless combat identification is specifically addressed (Joint Chiefs of Staff, 1993). Additionally, Department of Defense Directive 5000.2 will be modified to require evaluation of weapon systems combat identification capabilities at all milestone reviews.

Conclusions and Recommendations

Operation Desert Storm confirmed a gap in the application of technology to positively identify ground combat vehicles. The incidence of fratricide, unprecedented in 20th century warfare, confirmed the need for combat and materiel developers to carefully analyze the application of technology into our major weapons systems. Although we can acquire targets at previously unfathomable ranges, we can not always confirm positive combat identification. The identification of 'blind' spots highlighted our inability to positively identify ground combat vehicles.

Implementation of quick fixes during the Gulf War was a start in resolving the combat identification problem. Current initiatives in millimeter wave technology are similarly positive. In conjunction with these initiatives, the Department of Defense and the Department of the Army should pursue the following actions to further reduce the incidence of fratricide in future conflicts.

- **Continue to emphasize the importance of combat training and rehearsals** with particular attention placed on fratricide prevention.

- **Continue the development and distribution of training materials** such as the U.S. Army Armor School's Fratricide video cassette.

- **Continue to develop joint doctrine and train to it** with more Joint Training Exercises.

- **Include fratricide prevention in all Mission Needs Statements** and associated operational requirements documents for our combat systems.

- **Continue emphasis on fratricide at all Training Centers** (e.g., the National Training Center and the Joint Readiness Training Center).

- **Require combat and materiel developers to conduct a thorough risk assessment** for all systems, including fratricide prevention capabilities.

- **Enforce the requirement that combat identification capability be equal to engagement ranges** of particular weapons systems.

- **Continue to pursue all-service integration of IFF technology**, with specific emphasis on combat ground vehicles.

- **Closely monitor and enforce consideration of combat identification** capabilities at all Milestone reviews.

While the success of the Gulf War cannot be negated, the lessons learned from the high incidence of fratricide must serve as a reminder that requirements must drive technology, not vice versa. In the future, combat and materiel developers must anticipate and compensate for the consequences of partial or non-integrated application of technology. The ultimate solution must address multiple areas to include doctrine and procedures, organization, training, the application of advanced technologies, and hardware. Fratricide prevention must be a standing requirement for all combat and materiel developments. We owe our nation's Armed Forces nothing less.

References

Abbot, W.W. (1988). The Papers of George Washington. *Colonial Series*, Vol. 6, p. 120-123. Charlottesville, VA: University Press of Virginia.

Atkinson, R. (1994). Fratricide Problem Defies Decades of Efforts. *The Washington Post*. (April 15, p. A-19).

Cornelius, G. (1994). U.S. Forces Seek Affordable Solutions to Combat Identification Problems. *Signal*, Vol. 49, p. 72.

Cornelius, G. (1993). Halt! Bang! Who Goes There? *U.S. Naval Institute Proceedings*, 119/6/1084, p. 89.

Demonte, V. (1992). Avoiding Fratricide: Is the Endgame Solution the Answer? *Journal of Electronic Defense*, No. 15, p. 34-36.

Department of Defense. (1990). *Daily Press Briefing*, (Pete Williams), June 19. Washington: Author.

Department of the Army. (1993). *Proposed Operational Requirements Document (ORD) for the Battlefield Combat Identification System (BCIS)*, (Memorandum from the Office of the Deputy Chief of Staff for Operations and Plans), April 14. Washington: Author.

Department of the Army. (1992). *Revised Operational and Organizational (O&O) Plan for Army Combat Identification System (ACIS)*, (U.S. Army Training and Doctrine Command Plan), April 28. Washington: Author.

Department of the Army. (1992). *Fratricide: Reducing Self-Inflicted Losses*, Newsletter No. 92-4, p. 3. Fort Leavenworth, KS: Center for Army Lessons Learned, U.S. Army Combined Arms Command.

Department of the Army. (1982). *Identification Friend-or-Foe of Ground Combat Vehicles*, (Memorandum from the Office of the Assistant Secretary of the Army), June 2. Washington: Author.

Department of the Army. (1978). *Infantry Fighting Vehicle/Cavalry Fighting Vehicle (IFV/CFV) Cost and Operational Effectiveness Analysis (COEA)*, (Prepared by U.S. Army Training and Doctrine Command), October 15. Washington: Author.

Department of the Army. (1974). *Battlefield IFF for Tank Identification*, (Memorandum from the Office of the Assistant Secretary of the Army), February 15. Washington: Author.

Department of the Army. (1967). *United States Casualties from Own Fires*, (Report issued by U.S. Army Combat Developments Command), November 6. Washington: Author.

Department of the Army. (1967). *Antitank and Assault Weapons Requirements Study*, (Prepared by the U.S. Army Combat Developments Command), May 1. Washington: Author.

Department of the Army. (1963). *Combat Vehicles-1975*, (Report prepared by U.S. Army Combat Developments Command), November 15. Washington: Author.

Fussman, C. (1992). Casualties of War. *Life*, August, p. 70.

Gellman, B. (1991). 'Oh My God'-Then He Was Gone. *The Washington Post*, October 20, p. A-1.

Gellman, B. and Lancaster, J. (1991). Breakthrough to Avert 'Friendly Fire' in War is Years Away, Army Says. *The Washington Post*, December 13, p. A-10.

Gellman, B.; Gaillard, Jr., R.; and Shackleford, L. (1991). Gulf War's Friendly Fire Tally Triples. *The Washington Post*, August 14, p. A-1.

General Accounting Office. (1993). *Operation Desert Storm: Casualties Caused by Improper Handling of Unexploded U.S. Submunitions*, p. 7. Washington: Author.

Gordon, M.R. (1994). U.S. Jets Over Iraq Attack Own Helicopters in Error; All 26 On Board Are Killed. *The New York Times*, April 15, p. A-1.

Hackworth, D.H. (1991). Killed by Their Comrades. *Newsweek*, November 18, p. 46.

Hadley, J.F. (1994). Coming to Terms with 'Friendly Fire." *The New York Times*, February 24, p. A-19.

Harris, J.F. (1994). Building Force XXI: The Army's Special Task Force on Digitization. *The Washington Post*, April 24, p. A-18.

Hawkins, C.F. (1994). Friendly Fire: Facts, Myths and Misperceptions. *U.S. Naval Institute Proceedings*, 120/6/1096, p. 56.

Hewitt, B. and Demaret, K. (1992). Honor, Duty, Disgrace. *People Weekly*, June 4, p. 92.

Hughes, D. (1991). Small Firm Acted Quickly to Design, Field Infrared Beacons for Vehicles. *Aviation Week & Space Technology*, May 20, p. 54-56.

Johnson, R. and Solomon, C. (1991). Chilling Tapes Show How Soldiers Died in 'Friendly Fire.' *The Wall Street Journal*, November 7, p. A-1.

Joint Chiefs of Staff. (1993). *Combat Identification (CID)*. Washington: Author.

Lippman, T.W. (1991). Instances of Friendly Fire Are Not Surprising on the Battlefield. *The Washington Post*, February 3, p. A-23.

Lum, Z.A. (1993). My Brother's Keeper: Technology Tackles Fratricide Prevention. *Journal of Electronic Defense*, August 16, p. 49.

MacKay, R. (1993). Army Hopes ID Device for Vehicles Will Cut Friendly Fire Deaths. *The Washington Post*, March 8, p. A-4.

Morrocco, J.D. (1991). Gulf War Boosts Prospects for High-Technology Weapons. *Aviation Week & Space Technology*, March 18, p. 45.

Morzenti, J.T. (1991). Letter Insults Makers of Night-Vision Gear. *The Wall Street Journal*, November 27, p. A-9.

Office of Technology Assessment. (1993). *Who goes there: Friend or Foe?*, OTA-ISC-537, p. iii. Washington: Government Printing Office.

Paige, Jr., E. (1994). Fratricidal Friendly Fire Must End. *Defense Issues*, Vol. 9, No. 68, p. 1.

Roos, J.G. (1993). Army Enters Round Two of Four-round Anti-Fratricide Fight. *Armed Forces Journal*, November, p. 10.

Sa'adah, D.M. (1994). *Fratricide: Attitudes, Magnitude, and Change*, (Report to the 1994 Combat Identification System Conference).

Sa'adah, D.M. (1992). *Friendly Fire: Will We Get It Right This Time?*, (Paper presented to the 31st U.S. Army Operations Research Symposium at Fort Lee, Virginia), November.

Science Applications, Inc. (1979). *Non-Cooperative Battlefield Identification Friend, Foe, or Neutral: An Analysis and Conceptual Design*, (Unpublished), April.

Shrader, C.R. (1992). Friendly Fire: The Inevitable Price. *Parameters*, No. 22, Autumn, p. 31.

Shrader, C.R. (1982). *Amicicide: The Problem of Friendly Fire in Modern War*, p. 146. Fort Leavenworth, KS: Combat Studies Institute.

Starr, B. (1993). U.S. advances on battlefield ID. *International Defense Review*, December 26, p. 961.

Steinweg, K.K. (1994). *Piercing the Fog of War Surrounding Fratricide: The Synergy of History, Technology, and Behavioral Research*, p. 42. Carlisle Barracks, PA: U.S. Army War College.

Summers, H. (1995). War's unchanging truths can be ignored at our peril. *Army Times*, January 2, p. 70.

Trafford, A. (1991). Fallout from 'Friendly Fire.' *The Washington Post*, February 12, p. WH-6.

Tyler, P.E. (1991). Pentagon Rethinking Techniques to Prevent Attacks on Own Tanks. *The New York Times*, August 15, p. A-10.

Wright, G.M. (1993). *Scatterable Munitions=Unexploded Ordnance=Fratricide*, p. 46. Carlisle Barracks, PA: U.S. Army War College.

GETTING TO THE ON-RAMP OF THE INFORMATION SUPERHIGHWAY

Clyde Hewitt

The Federal Acquisition Streamlining Act provides an additional incentive to program managers striving to achieve increases in the productivity of their staffs through paperless acquisition processes. Key elements in any transition to paperless acquisition are technology, process, environment, training, and operations. These elements are addressed in the context of the program office, seen here as the on-ramp to the information superhighway.

Program managers are facing a new challenge in this era of downsized government: maintaining high levels of service to the customer by increasing the productivity of the program office itself. Changes to the acquisition process alone have not gone far enough to raise staff productivity. Increasingly, program managers must turn to technology to help solve their dilemma.

The new, automated paradigm of the traditional program office offers higher levels of productivity, yet it will fail to meet this goal without careful planning and an investment of resources and people. Properly executed, the transition to a paperless office should result in productivity increases that will outweigh the initial investment cost as well as the continuing costs of operations and support.

In addition, the Federal Acquisition Streamlining Act (FASA) provides a real incentive for program managers to move toward the paperless environment. FASA raises the ceiling for purchases allowed under the government's less onerous small purchase rules from $25,000 to $100,000. However, the Act also places a lower, interim threshold of $50,000 on the use of these rules by federal agencies, premised on whether the agencies can verify that they are performing 75 percent of their contracting actions using the electronic environment. Given that 77 percent of government contracting actions fall above this threshold in the $50-100,000 range, the 'carrot' here couldn't be made more

obvious.

FASA also supports the goal of reinventing government recommended by the National Performance Review. The Act requires the Office of Federal Procurement Policy to implement a government-wide Federal Acquisition Computer Network (FACNET) to promulgate the government's needs, receive solicitations, and provide public notice of contract awards. This totally electronic medium should greatly reduce the amount of paperwork required to order goods and services.

What Is Paperless Acquisition?

Paperless Acquisition encompasses the ability to identify needs, obtain appropriate approval authority, and assemble the documentation required to support the acquisition—usually in the form of a Request for Quote or Request for Proposal. It also promulgates needs to prospective vendors using EC/EDI or other electronic media, and gives prospective vendors the ability to respond electronically with proposals. Finally, it includes contract monitoring and the billing and payment process.

This all-inclusive vision of paperless acquisition is difficult to implement simultaneously. The current process involves too many players with dissimilar systems. A plan must be developed with integrated but limited steps built upon previous accomplishments, each supporting the final goal. This planning should start at the on-ramp to the information superhighway: the program office.

The typical program office has a mixture of automation technologies. It typically does not have established processes for managing information using automation. With the implementation of EC/EDI, program managers may now take advantage of the existing and readily available technology to increase program office productivity.

Automating an office also requires a management approach that embraces thinking 'out of the box' of the traditional paradigm. A successful transition toward a paperless environment requires equal effort by managers in five functional areas: technology, process, environment, training, and operations.

The Technology

The basic requirements for a paperless environment include an accessible storage location for information, a medium for information transfer, and a man-machine interface to translate the electronic information, such as a computer or printer.

Personal computers have replaced mainframe systems with remote termi-

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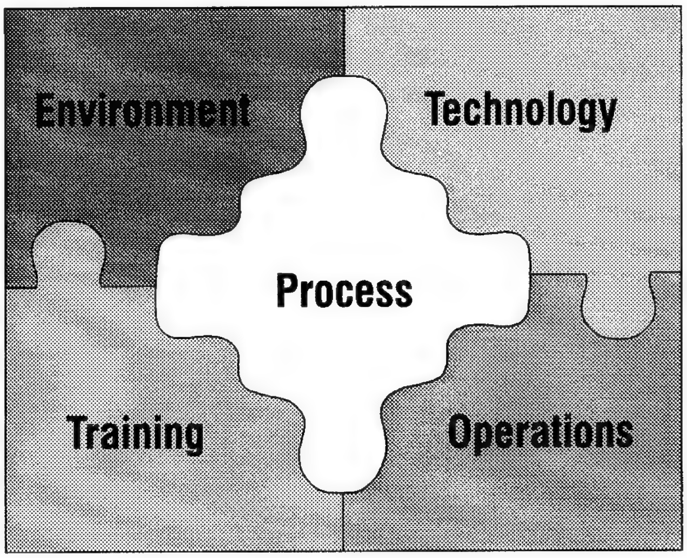


Figure 1. Elements for a Successful Paperless Acquisition Environment

nals as the most common man-machine interface, and have become the primary instrument of productivity for office workers. It's worth noting that an average performer may achieve a 10 percent gain in productivity by using a very fast computer instead of a slower machine. This performance increase would be worth $5,000 in the case of a typical knowledge worker earning $50,000 annually.

However, the backbone of the paperless office is the transfer of information, in electronic format, between workers using one of several media. Although the current medium of choice is the Local Area Network (LAN), it is not required for a paperless environment. Other methods include physically transferring floppy disks between machines and installing direct connections (e.g., dial-up bulletin board systems).

Today's work environment also extends beyond the office. Integrated Product Teams, or IPTs, may be geographically separated across a base or across the country. Portable computers accommodate this situation by expanding the electronic acquisition environment. These devices, when used with affordable high-speed modems and software that provide the same access to all users, extend the workplace throughout the world.

The LAN Outer Network (LON) offers users remote access to file servers and other services at nearly the same speed as a LAN. A recent Gartner Group study also found that productivity rose an average of 10 to 16 percent

as LONs came into use. Forrester Research estimates that there will be 22 million LAN users and 4 million LON users in the United States this year (Inc., 1994).

Regarding an accessible storage location for information, the key word is 'accessible' because it implies that workers have timely access to the information they need. The cost-effective solution for organizations larger than five people is a file server. Even though it is possible for larger organizations to use floppy disks to store information, the productivity lost in searching for and transferring information between machines quickly justifies the purchase of a file server.

This process eliminates the misunderstandings between the information source and the author.

THE PROCESS

Many organizations, both in the commercial sector and in government, attempt productivity advancements through investment in technology without examining the basic interoffice communications processes. Senior leadership is left questioning the value of new technology following marginal increases in productivity. If the 'paper process' is broken before technology insertion, the 'paperless process' will also be broken.

Examination of the interoffice communications process identifies three basic elements of the documentation process: information creation, coordination, and configuration control. Just as all optimized processes have only one owner, a single document owner, responsible for both the accuracy and dissemination of the information, is best empowered to manage the documentation processes. This single focal point avoids problems caused by having multiple revisions simultaneously circulating throughout program offices. Delegation of release authority to the owner is not required for process efficiency.

The document owner can choose between the centralized or the distributed document creation methodology. The centralized process, characterized by the document owner assimilating information from various sources, and then drafting a document, requires more time for a large document than the distributed process because of the coordination cycle with interested parties.

The decentralized document creation process is characterized by the document owner assigning writing requirements to various authors, and then serving as editor to ensure the final product is complete and consistent. This more difficult process requires detailed preparation since the owner must outline the requirements and expectations for each of the sections to each of the authors. This process eliminates the misunderstandings between the information source and the author. They become one and the same.

A carefully orchestrated document will also pass through the review and coordination cycle faster because each of the authors have a vested interest in its accuracy. As the document is completed, each section's successive draft can be reviewed to verify that there are

no disconnects or conflicting information in the overall document. The document's owner becomes a team leader, and serves as the final editor to ensure consistency and accuracy prior to release.

Once the documentation is completed, it should be coordinated both within and outside of the program office. The document owner may elect to use the serial or shotgun coordination method. The electronic serial coordination method has several inconspicuous time-saving techniques, when used with a process-focused coordination cycle. As the document progresses through the coordination cycle, each successive reviewer imbeds their comments directly into the document with full visibility of the prior reviewers' suggested changes.

The leading word processing packages, such as Microsoft Word for Windows, have an option of locking the original document and only allowing each successive reviewer the option of imbedding annotations. This method protects the original ideas from modifications while permitting the owner to easily review comments.

Reviewers using the latest version of Microsoft's Word For Windows have the option of making direct changes to the original document. The revisions can be preserved for review by the document owner by the use of color coded 'revision marks.' The document owner has the option of quickly scanning through the document, accepting or rejecting individual changes by simply the click of the mouse. If used properly, this methodology optimizes the coordination and correction process.

'Now Where Did I Put That?'

The personal computer has been a part of the acquisition environment for over a decade. With its introduction came the ability to individually customize computers according to personal preference. This personal freedom has also served as a barrier to productivity gains. There was a quiet revolution when personal computers were connected with LANs. No longer a collection of personal computers, but a 'system,' they must be managed using a 'systems approach' in order to realize their productivity potential.

With the expected growth in the number of electronic documents, program offices must adopt a storage and retrieval methodology in order to provide users universal access to documents (GSA, 1995). There are several different proprietary technological solutions that provide indexing and rapid text search capabilities. However, most government program offices can satisfy the majority of their document storage requirements without handcuffing themselves to a vendor. The use of a non-proprietary overall storage strategy provides an unobstructed upgrade path as vendors and software products evolve.

There are a few common sense rules to electronic filing.

There are a few common sense rules to electronic filing. First, there should only be one accessible copy of the document (excluding backups) available for review and coordination. It should be kept in a central location, such as a file server, which can be accessed from any

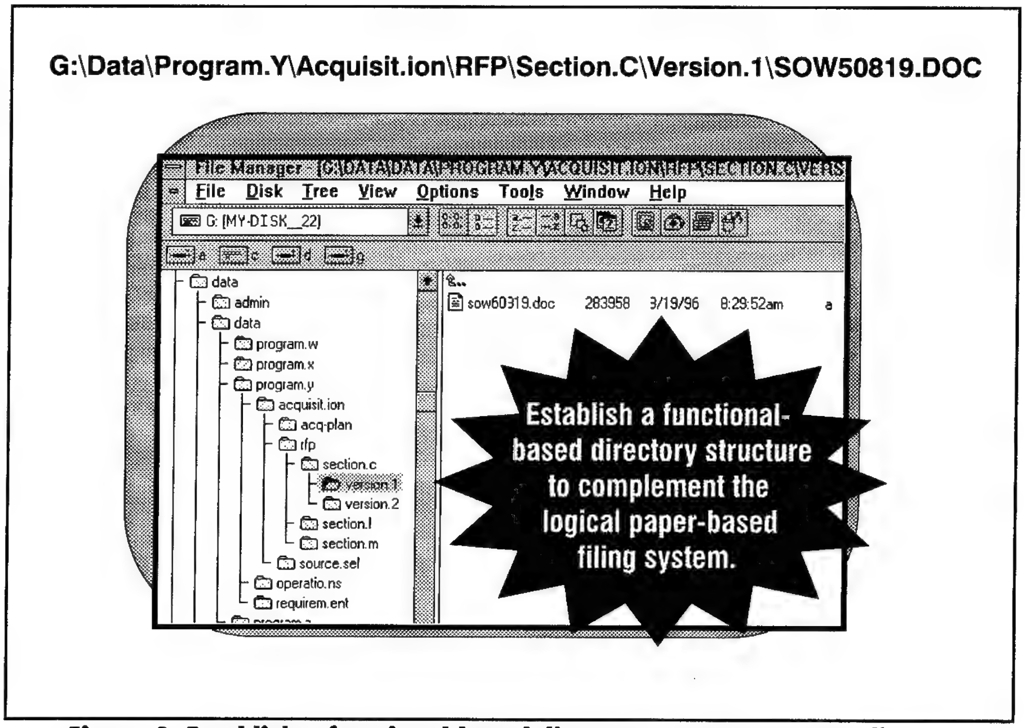


Figure 2. Establish a functional-based directory structure to compliment the logical paper-based filing system.

computer by an authorized user. Multiple copies of single document exacerbates the configuration control problem for the document owner by increasing the risk of losing comments generated in the coordination process.

The second rule is that the electronic filing system should match the schema of the office's paper system. Documents should be stored first by the users' access requirement, and second, by subject matter. This is the same procedure used in most paper environments. This schema is necessary to implement controllable and manageable security procedures.

Organizing files by subject matter is a difficult part of the automation process. Some organizations chose to organize files by the software application used to create a document (e.g., documents, briefing slides, or spreadsheets). This approach is not recommended since users naturally think in terms of subject matter, not application program, when searching for information. A second user searching for a document may not know which software application the document's creator selected; the process of locating information becomes a fishing trip through the file server. With the emergence of integrated multi-functional software applications, it is now possible to create a table of information in a word processor, database, spreadsheet, or presentation package. This will further make application-centered filing systems dys-

functional.

The nested directory approach is the easiest non-proprietary method for quick access to documents. For the MS-DOS and Windows users, the sub-directory structure expands to many levels providing ordered, logical storage locations. For the Macintosh users, nested folders provide the same functionality. Nested sub-directories, when set up properly, guide users in a logical direction to the desired document. One Air Force program office successfully used a nested structure to create and coordinate a large Request for Proposal in a paperless environment. New program office staff members quickly recognized the contents of the 'G:\DATA\ACQUISIT.ION\RFP\SOW\VERSION1\' directory, even without examining individual files.

After identifying the proper directory, the user must identify the correct document. Since a program office of 30 people can generate over a thousand files annually, a document naming convention permits quick file identification by other staff members. This convention should be tailored to the advantages of the computer environment. The DOS-Windows users face a limitation of 11 characters—eight + three. Macintosh and Windows 95 users don't face the same limitation. On networks with a mixture of systems, *all* users should follow the more restrictive schema to permit file access across platforms.

A file naming convention, when used with a detailed directory structure, can simplify information access without the need of additional technology. This process-centered solution can be tailored and grow as an organization's needs evolve. Some high technology solutions, such as some of the proprietary integrated scanner-storage systems, could lock a program office into a system that cannot be accessed in the future. Documents stored using these systems may not be accessible as standards evolve and the system is eventually replaced.

In summary, the electronic document creation and coordination process saves time and dollars. In the single-user environment, there are myriad ways in which a person may satisfy his or her own requirements. In a group environment where access, configuration control, and coordination are required, managers must establish a process that promotes a user friendly system. This requires the same forethought, effort, and teamwork that underlies the paper-filled filing cabinet.

Electronic Mail Process

Electronic mail, or e-mail, stands to revolutionize the communications process much the same as the telephone did in the late 19th century. E-mail permits communications across the fourth dimension (time) in virtually a ubiquitous state. Users will never experience a busy signal when trying to contact someone through e-mail. E-mail has two other desirable features: the capability to store information until the recipient is available, and the capability to serve as a record, permitting review and retransmittal if necessary.

E-mail can reduce the amount of time required to communicate informa-

tion when used to broadcast information to several individuals simultaneously. The use of mailing lists or bulletin boards facilitates convenient communication among several people, eliminating unnecessary meetings.

Since e-mail's infancy, it has evolved into an efficient, rapid communication system, capable of replacing most of the traditional 'snail-mail.' The next major revolution in e-mail, mass communications, is starting to emerge. The informal processes used in the past to control and prioritize information must be formalized to make effective use of the next generation of e-mail systems.

As e-mail use continues to grow, so does the users' distaste for the 'junk mail' that grows with it. Workers are drowning in data while searching for information. Many program managers receive more than 50 messages daily. There is a growing requirement to quickly identify the important mail, and eliminate the 'chaff.' Intelligence and Command and Control systems are starting to employ the use of Automated Message Handling (AMH) systems. This time-saving technology has been recently introduced into the commercial market, but users must follow more rigid processes to maximize the potential productivity. One of the better products for a LAN is 'beyond mail' which provides several nested layers of AMH, allowing customization at the group and individual level. With simple customization, the end user can have the software 'read' the message and take different actions depending on rules established by the user. As an example, the program manager may elect to automatically forward all incoming e-mail from selected senders to his deputy.

It is not necessary to have an AMH installed if users establish a process to quickly identify the important and routine messages. Most e-mail systems have an inbox which sorts unread e-mail and displays part or all of the 'subject' line. If all users preface the subject with a key word, then manual identification of important messages becomes a natural part of reading the mail. The key word should be short and standard across the organization. This manual categorization of messages simplifies any future AMH installation, and permits automatic sorting and filing.

At a loss for key words? Try the following:

HOT: for the most important messages

ACTION: for a tasking message

SUSP (date): for a message containing a suspense

MSG: for an outside message

CALL: for a telephone message

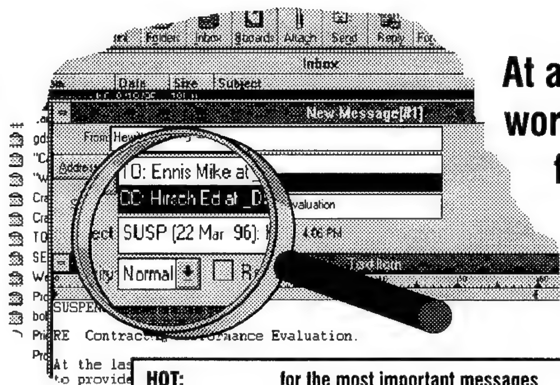
MTG: for a meeting notification

RFI: for a formal 'Request For Information'

???: for an informal 'Question'

INFO: for all routine, non-tasking e-mail messages

FYI: for all 'unofficial' For Your In-



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CALL:	for a telephone message
MTG:	for a meeting notification
RFI:	for a formal "Request For Information"
???:	for an informal "Question"
INFO:	for all routine, non-tasking E-MAIL messages
FYI:	for all 'unofficial' For Your Information or optional messages

Figure 3. Key Word Samples

formation, or optional messages

E-mail should also be 'sender friendly.' Some progressive organizations have recognized the fact that there can't be two hundred 'BOB@COM' users. Until the Internet has matured to provide a reliable directory service, make addressing e-mail a simple event. First, establish an e-mail naming convention which takes advantage of the services available today. Since most e-mail systems have an automatic sort function, always start your e-mail address with your last name, followed by your first name or initials. Finally, every organization should have a common mailbox, published to the world, which serves as the single entry point for official message traffic. In the event someone transfers, or is unavailable for an extended period of time, this 'clearinghouse' serves as a trap to prevent any important messages from ending up in the 'electronic dead letter file.'

The Environment

Information technology is a tool that must be purchased, properly used, and maintained in order for the workers to benefit from its potential to increase productivity. Just as there are incentives for contractors to invest in modern tooling under the assumption that it increases manufacturing productivity, so too are there incentives for investments

in the program office's information technology.

Program managers have an obligation to increase their staff's productivity. The senior leadership, including President Clinton and Ms. Preston, the Assistant Secretary of Defense for Acquisition Reform, has established the requirement that we change the way we are doing business.

A recent study, commissioned by the Air Force Materiel Command, examined why acquisition organizations were successful at integrating information technology. A common thread found among the best organizations was the presence of a champion. This individual, usually at the mid-to-senior level of management, spearheaded the information technology push. The champion usually held the vision of the paperless environment and fought for resources to make the investment (AFMC/XR, 1994).

It is, however, possible for a program office to integrate technology without a champion. Process Action Teams, Quality Circles, and other informal groups can provide the direction and leadership to move an office into the paperless environment. Despite their best plans, however, teams cannot be effective without the commitment of senior management. Senior management must make the necessary investments in technology and, as importantly, allow the organization itself to evolve.

...focus on automation as merely another means of eliminating jobs will inhibit teamwork...

Evolution, after all, is certain: the government continues to 'downsize' itself. Yet a focus on automation as merely another means of eliminating jobs will inhibit teamwork and, ironically, slow the introduction of information technology. The primary goal should be to increase office productivity through process re-engineering.

PEOPLE ARE NOT AFRAID OF CHANGE, THEY ARE AFRAID OF BEING CHANGED

How do you start the process of change? The introduction of information technologies can be met with resistance at all levels if planning is not performed first. Management should invest in employee training and develop automated processes to avoid technology shock. Many leading authors on process re-engineering stress that the key to successful change is in removing barriers that prevent people from changing. They have concluded that if you try to change people without removing their resistance to change, each successive positive factor will be met with an equally forceful excuse (Investors Business Daily, 1995).

One key to the acceptance of change lies in the principle that change is a neutral event, inherently neither good nor bad. People respond positively or negatively to change based on their perceptions of how it will affect them and their coworkers. If management's focus is on stressing the positive aspects of change while eliminating any negative outcomes, change will by accepted naturally.

The Roadmap

There are no silver bullets guaranteeing the successful insertion of technology. Nevertheless, there are groups of supporting ideas, linked by a common thread, that can be tailored to each organization's unique circumstances. Each area must be addressed; ill-considered actions or beliefs will undermine the technology insertion effort.

First, there will be an initial period of turmoil and growing pains which senior management should anticipate. One way to help sustain an organization during this dislocation is to highlight each small success, while continuing to emphasize the future benefits. Remind people that they are on the 'bleeding edge of technology,' and that the investment will be worth the short-term drawbacks.

Second, support the champions for their vision and leadership during this initial period, because the office 'naysayers' will feast during the early days (Rose, 1995). Management and the champions should establish mentors who can address problems quickly before they spin out of control.

Finally, network with other users who have identified the negative aspects of the technology being implemented and have turned these liabilities into assets. Other program offices who have implemented paperless acquisition processes identify the following barriers they've had to overcome: poor system performance, less than universal availability, lack of established communications processes, too much individual freedom of choice, and undesirable interpersonal issues. These barriers may be addressed as follows:

Poor system performance: One of information technology's greatest assets is its ability to keep up with a staffs' ability to create. Personal computers equipped with modern software packages indisputably increase users' productivity. The degree of productivity gained is in direct proportion to the amount of use the system gets. When users accept and use technology, productivity will also be maximized.

One major obstacle to the use of technology is poor system performance. Workers typically seek the most convenient method of performing their tasks. Unfortunately, an individual's search for what is personally the quickest or easiest method may often result in one that is less than optimal for a group. True, the use of technology can change the traditional office paradigm, but only if it has been prepared to support the actual workload (in other words, only if it's less trouble than it's worth). Technology incapable of supporting the demands of a modern office will lead to improvisation by the workers, not infrequently in favor of paper, rather than electronic, processes.

...what is personally the quickest or easiest method may often result in one that is less than optimal for a group.

As an example of a system that works, electronic phone message systems have now evolved to a point where they can reach the recipient anywhere at any time, with greater speed and accuracy than the pencil and paper method they replace. The CaLANdar

software package, for one, includes the ability to automatically tie into an electronic 'Rolodex' function with the click of a mouse, reducing potentially misunderstood or improperly copied phone messages. The software also has a feature that can automatically page the person being called. Once the message has been read, the product also provides an auto-dial and re-dial function to speed up the process of returning calls.

It's also worth noting that the $1000 difference in price between a marginal and a high-end system can be justified by a .5% increase in productivity over the computer's three years of use. In fact, the virtual elimination of the hourglass icon from the screen may increase worker productivity many times above the payback point.

Universal availability: E-mail serves as one of the best communications bridges to reach people away from the office, permitting round the clock access to information. When coupled with the automatic-pager function, users can be notified that an important e-mail is waiting for them. Part and parcel of this is the notebook computer, which must be compact and yet capable of interfacing easily with systems at the home office.

...individual freedom...is also the main barrier to any productivity gains made possible by Local Area Networks.

No communications process: Workers suffer less from the lack of information than they suffer from data overload. The sources of information are endless: electronic mail, electronic bulletin boards with multiple folders, even internal radio or television networks. All compete for our attention. This layering of communications media, in a misguided attempt to ensure each worker is reached, may well have the opposite effect: Redundancy can quash interest not only in the message, but in the medium as well. It is necessary to partition information into categories and use the one or two media necessary to reach the maximum number of members. The partitioning process should prevent the same information from reaching a single individual several times.

Freedom of Choice: This is probably the most controversial issue facing the introduction of information technology. Over 20 percent of the households in the U.S. now have computers. It is natural to want the same hardware and software suite at home as at work, but it causes major problems in a group environment. The least expensive investment to automate an office is the hardware and software. Different software and hardware suites add complexity to a LAN environment, require additional support staff (a big expense), and increased training requirements. While the previous items can be quantified, the biggest expense is, like an iceberg, below the surface.

Interoperability and immediate access of information in a paperless environment are two attributes that distinguish a single user from a group computing environment. An office with dissimilar hardware and software suites

can be glued together with modern tools. Unfortunately, the individual files retain the format of the creating software application. As an example, the two leading word processing software packages used in DoD are Novell's Word Perfect and Microsoft's Word for Windows, either of which is capable of translating the others' files. Unfortunately, the hidden cost of using two or more packages is the non-value added conversion time and the loss of unique editing features desired for group editing. The delays caused by conversion and the configuration control problem caused by multiple files stored in different formats also add no value. Finally, the presence of redundant software packages within an organization may limit the mobility of workers who aren't 'bilingual' or unnecessarily increase the cost of their training.

The individual freedom that came with the introduction of the personal computer is also the main barrier to any productivity gains made possible by Local Area Networks. No longer merely an assortment of 'stand alone' machines, personal computers are now part of an integrated system that must be managed like one.

Interpersonal Issues: Before the introduction of LANs, workers typically prepared and completed projects independently. The integrated program office now works in a spirit of teamwork, and the work ethic of teams is reinforced by network technology. One's work, even in draft form, is exposed for the consideration of other team members. By adding this deeper level of visibility, network technology also provides management, at least potentially, with a closer accounting of each individual's work effort. Understandably, this may cause anxiety (and resistance) among workers unaccustomed to getting 'in-process feedback.' Caution is advisable in structuring such feedback so that it will be accepted as 'process improvement' rather than being rejected as personal criticism (Sharon, 1995).

Resistance to technology may also arise from the fear that hard-won human contacts may be turned into faceless e-mail addressees. A recent Gallup poll discovered that over a third of white collar respondents didn't use computers for fear of losing face-to-face contact with associates (Miami Herald, 1995). They also feared their loss of privacy. Technology should not be viewed as a replacement for face-to-face contacts, but rather a medium to increase the total contacts between individuals.

Although the telephone took several decades to achieve universal acceptance, the computer revolution is proceeding much more rapidly as the technology becomes increasingly available, reliable, and inexpensive.

The Operations

An established paperless office environment requires continuous care and feeding or entropy will slowly force it back toward the paper-filled world. The care and feeding of a paperless system requires both a vision and effort. It also requires a constant source of funding. Properly administered auto-

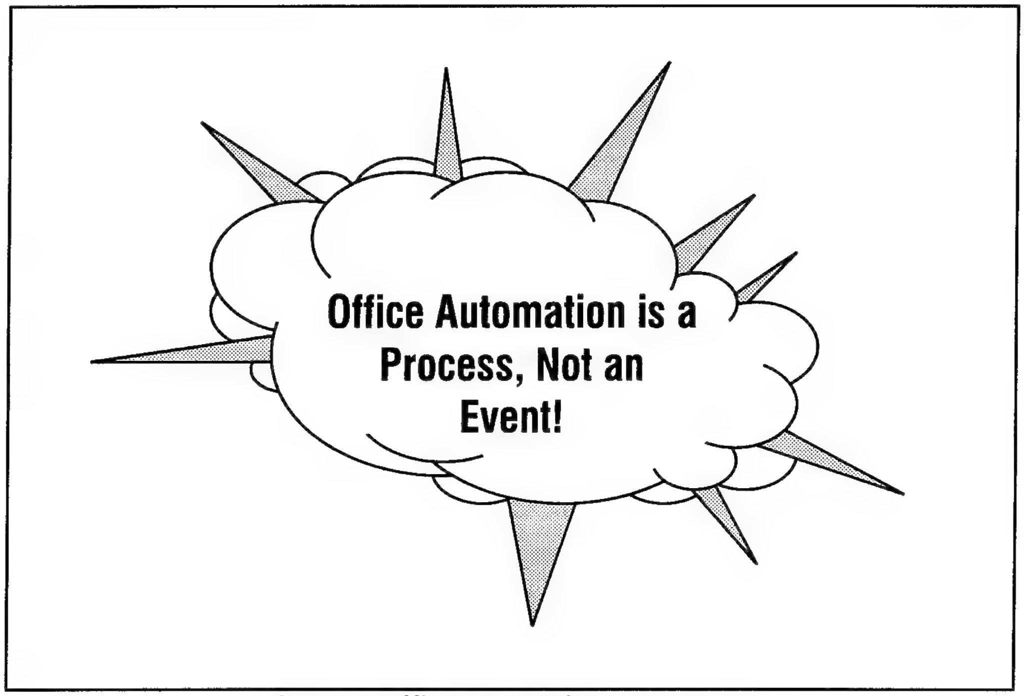

Figure 4. Office Automation Is A Process

mation systems rely upon a plan that levels the upgrade requirements across several years so that system upgrades happen as part of a process. Remember this key concept: Office automation is a process and not an event!

In the early days of personal computers, when the 80286 computer was just gaining acceptance in government, users felt that this computer would satisfy their needs forever. Today, users are aware that technology is growing at a frantic pace. Modern hardware and software tools are increasing the pace of productivity improvements. It was only four years ago that universally available automated performance reports didn't exist, but after implementation, one can only wonder how we could have done the job without them.

For the same price, personal computers are doubling their power approximately every 18 months. Organizations should attempt to keep everyone within two generations of technology to minimize support and performance impacts across a network. Failure to keep pace with technology results in having computers connected to a LAN that cannot support the latest generation of office automation software. A technological catch up requires a large influx of capital and effort, but not without the cost of political capital.

Organizations should budget replacing each personal computer in your organization every three years. The easiest way to level the budget is to replace one third of your computers each year, all for only $750 per person per year.

Adoption of a standard software configuration simplifies the insertion of new machines, since 'power users' will get the newest machines, flowing down the less powerful machines to less demanding users. After the third year, it may be necessary to replace only the computers, and not the monitors, further reducing the annual upgrade cost.

If an organization has not established an office automation process, and is temporarily forced to use older, less capable computers, then it becomes necessary to match the software and hardware capability to the slowest platform. It is wiser to keep an older version of software longer than planned if it still performs the function. Organizations should avoid the temptation to install the latest version of a software application before all computers are capable of providing satisfactory performance, so that they don't end up with a situation where the older machines fail to perform and thus frustrate users. In this case, the users may revert to the older software version to regain performance, compounding problems since documents created with different versions of the same software increase the configuration control nightmare.

As an example, one Air Force installation elected to retain an older version of word processing software for almost a year after a newer version was released. Their evaluation determined that the newer version of software didn't perform adequately on their older 386-based hardware platforms. They waited until a larger portion of the base had upgraded to newer 486-generation personal computers. In this instance, a prudent regard for organizational standardization necessitated keeping an older version of software longer than some users wanted. In the end, it was the best decision.

Since the operations function is a service function, customer focus should prevail when establishing operations policy. There are internal and external customers in a paperless environment. The external customers are the individuals who expect correct information on time. The internal customers expect computer systems available when they need them, with the tools and training necessary to optimize their performance. There are several processes necessary to perform these functions.

...personal computers are doubling their power approximately every 18 months.

The paperless environment, just as other processes within an organization, require a process owner. This process owner should be responsible for the operation and support of the entire paperless environment, not just the hardware and software. Depending on the size of an office, the position can either be full or part time. It is counterproductive to have several sub-process owners who are fragmented throughout the organization since a coordinated approach to a paperless environment is required to keep the system operating efficiently.

After identifying the process owner, we turn to managing the processes. The first process is the routine operation of the network, usually managed by a network manager or LAN administrator. The responsibilities of the network or LAN manager include establishing and

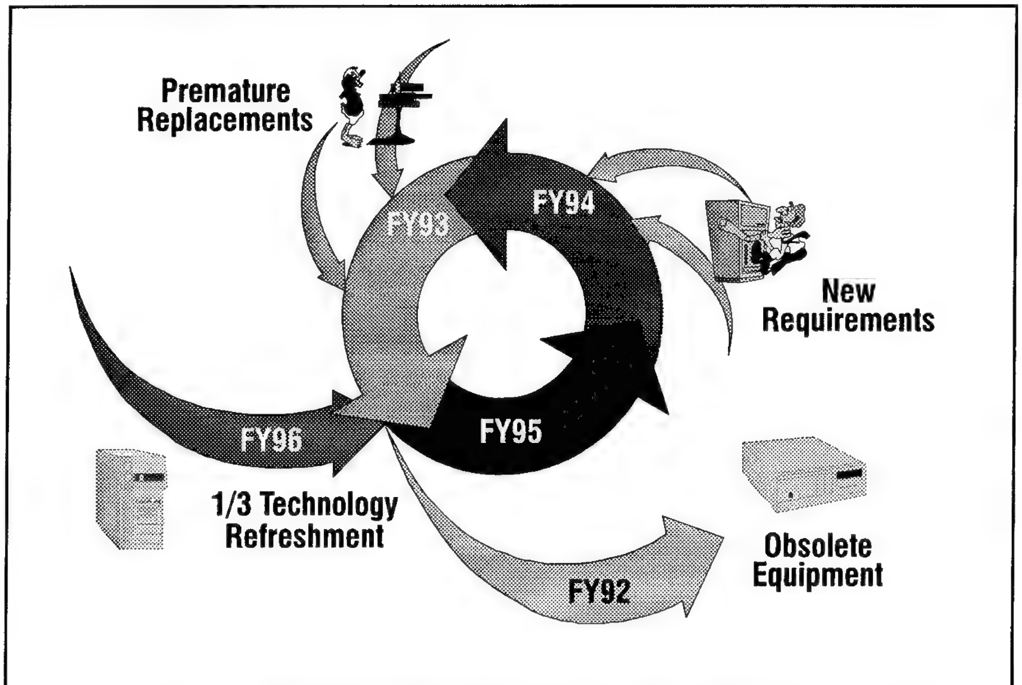

Figure 5. Computer Acquisition Requirements

maintaining user accounts, performing daily backups of the data, and conducting periodic virus sweeps to ensure data integrity. These functions are critical to maintaining the network and, by extension, to keeping the larger organization on track to the extent that it relies on the network. The position of LAN manager is a key one.

Unfortunately, LAN administrators are typically under-trained, partially because of the relative infancy of the career field and also due to the complexity of LANs (Rose, 1995). The best administrators are very pro-active, not only performing system backups, but monitoring system performance, performing virus scans, and making process corrections to maintain high performance. Examples of pro-activity include monitoring data files, transferring older files to a backup storage device when no longer needed, and making recommendations on when to upgrade hardware and software based on individual user's work profiles.

The best administrators recognize that they are part of a service organization, and that keeping the LAN available and functioning during peak work hours is essential to good customer relations. Scheduling LAN or file server maintenance on a Monday morning or a Friday afternoon, when the users are busy getting ready to depart to or getting back from trips, inhibits access to mail and files. This practice would naturally be eliminated in customer-focused operations centers.

A recent CompuServe survey re-

ported that half of the respondents had LAN outages of at least one hour a week, costing the companies a minimum of $500 an hour. Another Gallup survey showed that an average corporate LAN goes down 27 times a year, costing it's owners almost $3.5 million in lost productivity. (CompuServe Magazine, 1994) These costs should be considered when scheduling system backups during normal working hours. Complete system backups are best performed after hours, and always just before a hardware or software upgrade.

The best performances are not limited to LAN. If all notebook computers in the office pool are configured exactly the same, users don't have to go searching for applications, regardless of the notebook that is checked out. These notebooks should also have pre-loaded information to simplify the dial back procedure.

The valuable LAN administrator resources should not be limited to the functions listed above. Another sub-function of LAN administration process is the test and installation of software and hardware upgrades. 'Test' must precede 'installation!' Some organizations perform tests after installation, and risk losing data, or the LAN, and creating unhappy users. The acquisition community doesn't normally field untested weapon systems, and it shouldn't accept untested office automation systems.

A final sub-function of LAN administration is the installation and repair process. The Wall Street Journal recently reported that large organizations' operations budgets are almost $4,000 annually per personal computer. This expense is roughly divided up among the cost of the support personnel, system downtime, and system spares (Forrester Research, 1995). Since this number is almost twice the average cost of a quality computer, attempting to save funds by purchasing a less than quality system is not cost effective in the long term.

The Training

It's been said that if the cost of training seems expensive, one should consider the cost of ignorance. Although managers are, of course, free to select either informal or formal training as they prefer, there is little doubt that informal training will be more expensive in the end.

Program office workers require training in the technology adopted for use and, as importantly, in the organization's communications processes.

It is fairly easy to train users to use technology, given the multitude of available methods. These range from the formal classroom session to the use of several commercial videotapes and workbooks. These resources seem relatively inexpensive when one divides the purchase cost by the number of workers to be trained.

...an average corporate LAN goes down 27 times a year, costing it's owners almost $3.5 million...

Training workers about an organization's communications process is more difficult. The first requirement, after establishing standards, is to docu-

Figure 6.

ment and baseline the process so that it can be promulgated throughout the organization. This task is difficult because of the desire to evolve the processes through continuous improvement. Once the processes are baselined, the users can be trained on the process. Finally, the process owner should conduct periodic inspections to ensure that the processes are being followed.

There are several techniques that encourage the use of standard processes. Leveraging individual creativity identifies time saving methods that can be exploited through technology. Templates within software applications, easily accessible to each user by 'hot keys' or 'macros,' reduce the time required to perform many basic functions, such as FAX Forms, pre-formatted official memorandums, and signature blocks.

System administrators also require specialized training in LAN and wide area net operations to ensure the system performs well. Organizations should not attempt to underinvest here. And system administrators must be knowledgeable in the operations of their organizations. They should know who needs access to the different types of information and where it is normally kept. This individual has the responsibility of designing a physical computer architecture and a functional allocation of computer disk space to satisfy the needs of the customer. Senior managers are challenged to serve as a mentor to their System Administrators and keep them informed of the

organization's information needs.

The acquisition community is entering a period of rapid change, and the pace of change is getting faster. There is an opportunity to fundamentally alter the way the acquisition community conducts business. This opportunity is fueled partially by technology, and partially by changing attitudes in the government. The signing of FASA has ushered in not only an era of acceptance to change the way we do our business, but a mandate to change.

In summary, program managers have a requirement to enter the electronic age. This task should be approached with at least the same attention to detail as is applied to the other acquisition programs. The acquisition community must resist narrowing the focus on the technical solution and instead invest in processes that the basic technology supports. If an organization's basic communications process are chaotic before automation, the existing inefficiencies will only occur faster after automation.

REFERENCES

Compuserve Magazine. (1994). Telecommunications Management Review. December 11.

Forrester Research. (1995). Managing Desktops Costs Plenty. *Wall Street Journal*, February 16, p. A-1.

Gallup Poll. (1995). Cyberphobics Galore. *Miami Herald*, January 2, p. 22.

Gartner Group. (1994). Technology Premier Issue. *INC.*, p. 18.

Investor's Business Daily. (1995). *Lessons for CIOs*. January 31, p. A-8.

Rose, I. (1995). Retooling the Information Systems Profession. *Journal of Systems Management*, January-February, p. 7-13.

Sharon, Dr. A. (1995). *Information Technology Skills of Federal Employees-A Survey Report*. Washington: U.S. General Services Administration.

U.S. Air Force Materiel Command (AFMC/XR). (1994). Small Business Innovative Research Contract. Washington: Author.

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THE IMPACT OF TECHNICAL DATA TRANSFER PROBLEMS DURING A TRANSITION OF WEAPONS SYSTEM PRODUCTION BETWEEN NATIONS

Michael E. Schaller

In the early 1980s the U.S. Army sought to replace its aging fleet of M102 105mm-towed howitzers with the British M119 under a Non-Developmental Item (NDI) acquisition strategy. This paper addresses the problems experienced, their possible causes and effects, and provides a list of lessons learned. Finally, recommendations are made to help future program managers mitigate or avoid the problems experienced by the M119 program.

Although the M119 program has been hailed as a very successful NDI acquisition, there were problems encountered by the program office along the way. The most significant of these was the transition of production from the original manufacturer, Royal Ordnance, to the U.S. arsenals at Rock Island, Illinois and Watervliet, New York. The major cause of this transition problem was the transfer of the Technical Data Package (TDP).

The TDP provided by Royal Ordnance was not, and never would be, found acceptable under U.S. standards. Additionally, the Program Office was restricted in its ability to mitigate some of the potential risks associated with TDP transfer. All in all, the TDP transfer problem cost the program an incredible amount of time and money.

All of the data presented here (with the exception of Reese and Fowler, which are periodical articles) were drawn from American sources. Neither Royal Ordnance nor the government of the United Kingdom provided input to this work. Representatives from Royal Ordnance were contacted via facsimile but did not respond. One source did agree to discuss issues contained in this

work based on a grant of anonymity. The author was also provided multiple examples, from multiple sources, of General Officer "meddling" and pressure in the M119 acquisition process.

FROM WHENCE IT CAME

In late 1983, the U.S. Army initiated a program to redesign the structure, roles, and missions of its light infantry divisions (LIDs). Within this redesign of the LID, the decision was made to procure "a longer range, more lethal artillery weapon" (Army Magazine, 1986, pg. 365). Importantly, the Army Chief of Staff (CSA) "also established an extreme sense of urgency for fielding the light division" (U.S. Army ARDEC, 1987, pg. 1). The program direction that devolved from this CSA guidance was to search for a howitzer that the Army could "field immediately" (U.S. Army ARDEC, 1987, pg. 1). In terms of the M119 program, "immediately" was translated into a "must have" fielding date in selection criteria that would fall within fiscal year 1987 (U.S. Army ARDEC, 1987, pg. 3).

In January 1984, Army headquarters tasked the Army Materiel Command (AMC) to search the inventory of U.S. and NATO 105mm howitzers and develop a list of those capable of meeting the LID requirements for light infantry (HQ, U.S. Army AMCCOM, 1985, pg. 1). Over the course of the next five months AMC evaluated 20 weapons and eliminated all but four. It was from these four that the British Light Gun, the L119, was determined to be the "best candidate for the LID" (U.S. Army AMCCOM, 1985, pg. 2). The ARDEC briefed these results to the CSA in May 1984, recommending the L119.

The Chief's decision was to lease a sufficient number of L119 howitzers for testing, and to develop new 105mm rounds for increased range and lethality (HQ, U.S. Army AMCCOM, 1985, pg. 2). After this initial testing was successfully completed, the weapon was type-classified in December 1985. Production contracts were prepared and a licensing agreement between the U.S. and Royal Ordnance was negotiated the following year (Armament and Chemical Acquisition and Logistics Agency, 1994, pg. 1).

The licensing agreement was made necessary by the Army's decision to purchase only a portion of the weapons desired from Royal Ordnance, with the remainder being produced domestically. It authorized American production of the L119 and established royalty payment procedures.

The decision to produce the M119

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domestically was based on two factors. The first, maintainability, stressed concerns about the availability of spare parts and the lack of control over an offshore source. Second and conceivably more important, there were nationalistic considerations; specifically, the maintenance of the mobilization base. Each had an impact on the decision (U.S. Army AMCCOM, 1987). Based on these and other factors, the Government opted to perform production at Watervliet Arsenal, which would manufacture the cannon assembly, and Rock Island Arsenal, which would produce the trail assemblies. The two pieces would be assembled, and the howitzer completed, at Rock Island. These two arsenals, then, had to prepare their facilities for the gradual transition of production from Royal Ordnance.

The license agreement cost 1,150,000 pounds sterling for 145 complete howitzers, 20 carriage assemblies, 15 trail assemblies, additional parts and equipment from the U.K., and the royalty fees and TDP required for subsequent U.S. production (U.S. Army AMCCOM, 1987, pg. 1). The production contracts were signed in July 1987, with Royal Ordnance operating off what was considered to be a warm production base. Royal Ordnance delivered the first production guns to the U.S. for Production Verification Tests in early 1988. Production began in America in fiscal year 1988, with the first howitzers coming off the line in October 1990 (Reece, 1991, pg. 718).

Impact of the Technical Data Package

A technical data package defines the system's design configuration and the production, engineering, and logistics support procedures required to ensure the system's adequate performance. The TDP consists of all applicable technical data, including drawings, quality assurance provisions, and packaging details (DSMC, 1991).

As part of its licensing agreement with the U.S., Royal Ordnance agreed to provide the Americans with a TDP that was "sufficient to manufacture in the U.S." (Armament and Chemical Acquisition and Logistics Agency, 1994, pg. 1) and which "consists of all the recorded 'know-how' required to manufacture, assemble and test...the L118/ L119 gun" (Nathan, 1995, January 30). What Royal Ordnance actually provided was much less: an archival set of drawings, a set of manufacturing drawings (which showed in-progress drawings, some gage and inspection drawings), an illustrated parts catalog (similar to our -34P technical manuals), and a Final Inspection Record (Nathan, 1995, January 30). While all of these documents are valuable in and of themselves, they did not satisfy the U.S. Government's requirements for TDP content and accuracy of drawings.

...the TDP as delivered was "'archival', grossly inaccurate, and missing essential manufacturing data"

According to the original schedule, the technical data package was to be delivered in January of 1986. It was not

actually received, however, until August of that year, due to problems that Royal Ordnance experienced in collecting and assembling the required information (Nathan, 1994, pg. 18). Additionally, the TDP as delivered was "'archival', grossly inaccurate, and missing essential manufacturing data" (Armament and Chemical Acquisition and Logistics Agency, 1994, pg. 1).

The engineers at Rock Island and Watervliet recognized that this TDP was of little use to them and returned it to Royal Ordnance for rework. Royal Ordnance claimed in response that the Technical Data Package met the requirements, but agreed to fix it for an additional cost of $4.75 million. The Americans in the program office felt "in a bind" at this point: Royal Ordnance had failed to comply with the licensing agreement and should fix the Technical Data Package at no cost, yet there was severe pressure to get the howitzer into the system quickly. As a result, the program office opted to avoid lengthy litigation by paying Royal Ordnance to rework the TDP.

"Royal Ordnance had no idea what an Americanized Technical Data Package looked like"

This revised TDP still failed to meet requirements in August 1987 (Nathan, 1995, January 30). Again, the problems centered on the actual quantity and detail of information being provided. Schedule slippage, coupled with the delay engendered by Royal Ordnance in modifying the original TDP, prompted the project office to have this version fixed at ARDEC and at the arsenals in Rock Island and Watervliet. The cost of this domestic fix was $3.0 million (Armament and Chemical Acquisition and Logistics Agency, 1994, pg. 1). The end result was a TDP nearly $7.75 million over budget and more than three years' late.

These problems highlight the potential difficulty in dealing with sources other than those routinely involved in production for the U.S. Government. This is not to say that similar problems never occur with domestic manufacturers. Rather, the problems were significantly exacerbated by Royal Ordnance's inexperience with the American "way of doing business."

One of the critical requirements of an American technical data package is that it provides the information required by manufacturers to "produce to [the] TDP with stringent configuration management requirements" (Nathan, 1994, pg. 1). This requirement caused a significant portion of Royal Ordnance's TDP problems. The company produced the L119 in its own plant using a "fit at production" philosophy, so that the accuracy of drawings used on the production floor was less critical. However, Royal Ordnance had difficulty putting this process on paper. As one member of the project team stated, "Royal Ordnance had no idea what an Americanized Technical Data Package looked like" (Nathan, 1994, pg. 1).

Furthermore, the "British Technical Data Package also had a substantial amount of sole source or proprietary components, which is unacceptable in a U.S. Technical Data Package" (Nathan, 1994, pg. 2). The British procurement process does not require competition. As a result, their system

has no need for the TDP information which is typically used by Americans to facilitate competition among different commercial sources or, alternatively, to produce the component in a U.S. Government arsenal.

The real issue had little to do with the TDP itself, but rather with the difference in the production philosophies of the Americans and Royal Ordnance. Essentially, at Royal Ordnance each howitzer was built individually, with pieces machined to fit each weapon regardless of design drawings. These production floor changes were seldom, if ever, reflected in the technical drawings included by Royal Ordnance in the TDP it provided to the U.S. Essentially, the TDP failed to reveal the actual process followed in manufacturing the L119.

Given no requirement for changes to be tracked or reflected on drawings, configuration control of the L119 was also a problem. In fact, with no standard manufacturing process and no approved design, it seemed nearly impossible that two identical howitzers could roll off the production line.

Fixing the Problems

Based on the differing views of production and configuration management between the U.S. and Royal Ordnance, it isn't surprising that the TDP provided by Royal Ordnance would fall short of what U.S. manufacturers required to produce the M119.

The drawings provided by Royal Ordnance in August 1986 were really nothing more than a rough draft for what the U.S. government would consider a TDP. To achieve that level of accuracy and detail, Royal Ordnance had first to update the TDP they were using in line with the howitzers they were producing. This required that they revise virtually every drawing to reflect the waivers, deviations, and engineering changes already approved on the shop floor, then implement a configuration management and status accounting system to ensure that any subsequent revisions were recorded on the spot (Nathan, 1994, pg. 2). This process, undertaken by Royal Ordnance with extensive U.S. help, took well over a year. Once completed, the technical data products provided by the company's manufacturing element improved significantly, although they remained below U.S. standards.

The impact of these TDP problems was enormous, driving program cost $24 million above budget and delaying initial fielding by more than three years. The TDP itself cost nearly eight times the amount originally planned.

In the absence of a good TDP, the initial 1984 estimate for retooling Rock Island and Watervliet arsenals to produce the M119 was $8 million, based on historical data from production of the M102 howitzer. This history failed to provide an accurate projection of the requirements for the M119. In early 1985, the first revised estimate increased tooling costs to $10 million. Another refinement, which took place just prior to the receipt of the first Royal Ordnance TDP, raised the estimate to $13 million (Nathan, 1995 [January 30], pg. 1), or $4.75 million each for Watervliet and Rock Island in fiscal

year 1987, with roughly an additional $3.5 million for Rock Island alone in fiscal year 1988 (HQ, U.S. Army AMCCOM, 1987, pg. 3). However, the eventual receipt of the TDP, and the subsequent revisions made to it, resulted in a final estimate for tooling costs of $23.3 million.

Army and AMC staffs approved these funds, and production tooling began in March 1990 (Nathan, 1995, January 30). As a result of TDP problems, tooling costs for the arsenals were almost three times the original estimates.

However, because production tooling (and production itself) could not begin in the U.S. until a usable TDP was developed, the timeliness of American production was threatened. The transformation of the production lines at both arsenals depended on the ability of their engineers to estimate and forecast equipment and material requirements. This estimation process, usually based on some form of technical drawing, is critical to a rapid transition. Facing an ever increasing amount of pressure, "(T)he arsenals could not afford to wait for an Americanized Technical Data Package in order to start production" (Fahey, 1994, pg. 2). Instead, the process went ahead using data gathered through a concurrent engineering effort at Rock Island. In this process,

> (A) concurrent engineering team (Arsenal production, ARDEC engineers, production planners, quality control and product assurance and logistical people) [got] together to review and mark up drawings to make them suitable for U.S. arsenal approval (Fahey, 1994, pg. 2).

To expedite the overall effort, the concurrent engineering team at Rock Island forwarded the 'Americanized' versions of individual Royal Ordnance TDP drawings to the manufacturing floor as they were finished. This process, which was both time and manpower intensive, produced a TDP that was "not an optimal Technical Data Package, but was a Technical Data Package that the arsenals could produce to" (Fahey, 1994, pg. 2).

As of the summer of 1995, there is no competitive TDP available. Production is still being conducted from Ordnance Drawings produced at Rock Island Arsenal.

The problems with the M119 technical data package during transition of production to the U.S. provide an important source of information for future program managers.

1. Technical data transference is critical if production transition is to be effective. Virtually every problem associated with the domestic production of the M119 stems from the inaccuracies and problems with the Technical Data Package. No significant problems were experienced with the actual physical reconfiguration of the arsenals to do the production. Once the required information was available, the arsenals functioned as they were supposed to. In this case, Royal Ordnance was not necessarily unwilling to provide accurate

technical data. In fact, due to the structure and process by which they had been producing the L119 for the U.K. Army, they were unable to provide an American quality TDP.

2. Foreign suppliers may or may not understand our acquisition practices. Clearly, Royal Ordnance did not. Issues which are peculiar to U.S. acquisition process in general, and to TDPs in particular, such as proprietary or sole source information restrictions, the level and degrees of accuracy for technical drawings, and rigidness of configuration control can introduce serious problems into the acquisition cycle if not handled properly.

3. Buying in a 'rush' is dangerous. With the selection of an existing system, the Army hoped to procure a weapon system in less time than that required for a full development. The use of a Non-Developmental Item (NDI) strategy is not at odds with using a methodical and structured approach. However, in addition to the time savings offered by NDI, in this case senior Army officials outside the acquisition chain tried to gain additional time by rushing the procurement cycle. As a result, proper investigation and confirmation procedures were not used to assure Royal Ordnance's capability to perform to contract. The pressure to get the howitzer into U.S. production forced the program office into an untenable position in terms of contract clause enforcement. In this case, the buyer 'needed to buy' more than the seller 'needed to sell.' As a result, the program office had difficulty forcing Royal Ordnance to live up to the agreements of the contract; it was faster to concede and pay the extra money than it was to fight it out.

4. Trying to fix something after the fact is hard to do. Once the contract was awarded to Royal Ordnance, it became extremely difficult to 'force' them to change and do things our way. This was the case with the discrepancy over the original Royal Ordnance-delivered TDP with regard to its compliance with the license agreement. Royal Ordnance claimed compliance, and it would have been extremely costly in terms of time and money to force them to do something which might possibly have been clarified easily or at little cost prior to execution.

Because the accuracy and completeness of technical data is critical, program offices need to devote time, money, and effort to researching a potential supplier's ability to comply with U.S. TDP requirements. Comprehensive reviews of technical data and drawings are the absolute minimum required. A survey of the potential supplier's manufacturing process and configuration control systems are also extremely important.

The real key to success in this area is

the determination that the production process in use by the potential supplier satisfies several requirements. First, the process in use must comply with the process that the manufacturer says (and documents historically) it is using. Second, the process in use must clearly produce the product in conformance with the applicable drawings. Finally, there must be an effective management system in place to monitor and document configuration management.

Clearly the most difficult problem to overcome is that of 'outside' meddling...

The responsibility to ensure that our suppliers are fully aware of U.S. Government-peculiar requirements rests on the U.S. procurement officials involved with the acquisition. Without a clear understanding of these requirements the supplier may very well find that, like Royal Ordnance, it is willing to comply but it is unable to do so. In the case of the L119, Royal Ordnance was already producing the system and their customers were very satisfied with the results. It was only when the U.S. tried to enforce compliance with its TDP standards that Royal Ordnance started to have problems. Early and continuous interface involving representatives from both sides can be an effective problem resolution technique. The program office and Royal Ordnance did, in fact, meet repeatedly, but it was after the contracts were signed. By that time, Royal Ordnance was committed to standards with which it could not comply.

The purpose of every acquisition should be to get the piece of equipment which best satisfies the user's need in a timely manner. In order to satisfy that purpose, we have a structured and methodical approach by which we procure items. By using selected strategies, such as NDI, we can efficiently reduce the lag time between requirement identification and need satisfaction. Unfortunately, our acquisition strategies are often distorted by political realities. Clearly the most difficult problem to overcome is that of 'outside' meddling in the procurement process.

Procurement professionals need to be shielded from the unrealistic demands imposed by 'interested' parties. A solid, logical, and realistic baseline schedule and process by which the program office gathers information and makes decisions is critical in preventing outside meddling. Program members need to be especially attuned to the political winds and their effects on the program. Early identification of potential problems are a significant step towards rational solutions.

Early identification of potential problem areas is a key to success. As with technical data transfer, all aspects of contract performance need to be explored early in the process in order to identify and resolve issues prior to award. In that way, potential sticking points between the two parties can be resolved in a cooperative atmosphere, rather than in an adversarial conflict revolving around interpretation of a contract clause after the fact. Had the U.S. conducted a detailed investigation into the practices employed by Royal Ordnance (i.e., technical drawing, configuration management, and documentation control procedures) before select-

ing the company as the source for its new howitzers, perhaps the outcome would have been different. If done prior to award, the changes to Royal Ordnance's process could have been made a condition of the award. If Royal Ordnance declined to accept 'our way of doing business,' we would be free to find another source or solution.

With the decision to replace the existing fleet of M102 howitzers, the Army hoped to procure a major weapon system under the NDI approach. This approach, it was hoped, would get the howitzer into the field much more quickly than if the weapon were to be developed from scratch. However, due to multiple factors, it was decided that only a portion of the weapons would be produced offshore, with the remaining weapons being produced within the U.S. arsenal system. This plan, while not unsound, ran into some difficulty. From the inception of the program, three relatively senior General Officers applied and maintained pressure on the program office to get the howitzer fielded quickly. As a result, the process, already shortened by the removal of development, was rushed further. With the selection of the Royal Ordnance L119 as the weapon of choice, events came together to portend trouble. The combination of the processes by which Royal Ordnance made the L119, the need for domestic U.S. production, and the time pressure being applied were directly at odds with each other. Because time was not available to investigate and assess the methods Royal Ordnance used to manufacture the L119, the program office never knew that the British manufacturing philosophy was radically different than that required for U.S. Government contractors. Additionally, it did not know that the drawings being used by Royal Ordnance did not really reflect the products being produced in any true engineering sense of the word. Finally, because the time was not available to explore Royal Ordnance's ability to provide an American standard TDP, the U.S. Government did not know until after the contract was signed that Royal Ordnance would not be able to provide a Technical Data Package suitable for use in a U.S. production facility. Thus, we entered into a contract with a party who was unable to complete their portion of the agreement. The program office was rushed into getting the system on contract without being given adequate time to investigate the full impact that the transfer of the Royal Ordnance TDP would have on our acquisition. The fault does not lie with Royal Ordnance. They had proven, over time, that they could produce a quality weapon system. However, the methodologies and requirements of the U.S. acquisition community were totally foreign to the decision makers at Royal Ordnance. This, coupled with unrealistic time demands on the decision makers on the U.S., led to a TDP problem which had, and continues to have, a significant impact on the M119 program. Although the acquisition of the M119 has been called a "model of future procurement" (Reece, 1991, pg. 718), it is

The fault does not lie with Royal Ordnance. They had proven, over time, that they could produce a quality weapon system.

also correct to state that the acquisition of the M119 howitzer should serve as a 'how not to' model for the problems associated with the transfer and management of technical data.

References

Armament and Chemical Acquisition and Logistics Agency. (1994). *M119 105mm Howitzer: Lessons learned on Non-Development Item Program*, (White Paper), April 20. Author.

Army Magazine. (1986). *M119 105mm Towed Howitzer* (Equipment description), October.

Defense Systems Management College. (1991). Glossary: Defense Acquisition Acronyms and Terms, September. Fort Belvoir, VA: Author.

Fahey, K. (1994). Response to request for information from Development Project Officer, M119A1 105mm Howitzer System, December 8.

Fowler, W. (1991). The Royal Ordnance 105mm L118 Light Gun-An Ugly Duckling Makes Good. *Asian Defence Journal*, January.

Headquarters, U.S. Army Armament, Munitions and Chemical Command. (1992). *Briefing Packet, Title: M119A1 105mm Howitzer, U.S. Technical Data Package*, March 17. Rock Island, IL: Author.

Headquarters, U.S. Army Armament, Munitions and Chemical Command. (1987). *Memorandum to LTG Skibbie, Subject: M119 Howitzer Trail Production*, March 17. Rock Island, IL: Author.

Headquarters, U.S. Army Armament, Munitions and Chemical Command. (1985). *Non-Development Item (NDI) Program M119 105mm Howitzer* (White paper), March. Rock Island, IL: Author.

Nathan, J. (1995). Response to request for information from Weapon System Manager, M119A1 105mm Howitzer System, February 19.

Nathan, J. (1995). Response to request for information from Weapon System Manager, M119A1 105mm Howitzer System, January 30.

Nathan, J. (1995). Response to request for information from Weapon System Manager, M119A1 105mm Howitzer System, January 24.

Reece, Col. R.G. (1991). The M119 and NDI success story. *International Defense Review*, July.

U.S. Army Armament, Munitions and Chemical Command. (1987). *AMCCOM FY 87 Acquisition Plan No. 87-1 for M119 Howitzer, Light, Towed, 105mm*, revised October 7. Author.

U.S. Army Armament, Munitions and Chemical Command. (1985). *Decision Coordinating Paper for Howitzer, Light, Towed, 105mm: M119*, December 18. Rock Island, IL: Author.

U.S. Army Armament Research, Development and Engineering Center (Fire Support Armament Center). (1987). *A systems analysis and rationale for the selection of the UK L119 howitzer for the Light Infantry Division Artillery*. April. Picatinny Arsenal, NJ: Author.

U.S. Army Logistics Management College. (1994). *MAM Course Reference Book #1*, July. Fort Belvoir, VA: Author.

BATTLE LABS: TOOLS AND SCOPE

Julian Cothran

The Battle Lab is a tool for the rapid insertion of new technology into weapons systems and for the early evaluation of potential military components and experimental systems. It can yield cost savings to project managers and system users. It is multi-faceted, meeting such diverse requirements of the acquisition process as the engineering test beds used by the project manager and the simulations used by commanders, planners and others for wargaming. This paper describes the desired integration of battle labs with test beds, and how test beds produce: a) the required fidelity of input for Battle Lab demonstrations; and, b) experiments with evolving technological advancements.

According to General Fredrick M. Franks, Jr., former commander of the U.S. Army Training and Doctrine Command (TRADOC):

> (W)hat we wanted to do in TRADOC was provide ourselves a means—given resource constraints—to take emerging ideas from recent battlefield experiences such as Just Cause and Desert Storm and continue to experiment with those ideas and with technology insertions that could be applied to furthering our warfighting capabilities using simulations as well as some actual prototype (hardware) systems tied in with the simulations (Roos and Franks, 1992).

This can be accomplished by "networking simulators that offer a safe, cost effective environment augmenting live field exercises; one in which we can afford to exercise all the components of today's combined arms teams," according to George T. Singley, III (Singley, 1993). Singley adds:

> (M)aterial developers will shorten acquisition time while reducing both costs and development risks by employing Distributed Interactive Simulation (DIS) during concept definition, concept exploration, design, MANPRINT assess-

ments and prototyping.

Simulation also allows for quicker, more effective trade-off studies. The result is clearer requirements in less time and at lower cost (Franks and Ross, 1993; Slear, 1992).

Gen. Franks and General Jimmy D. Ross, former commander of the Army Materiel Command (AMC), agreed that:

> Battle Labs' requirements for rapid insertion of new technologies into systems via components and experimental systems will be tested iteratively, demonstrated and evaluated for military value. To a much greater degree than in the past, this process is based on simulation of both the physical system and its battlefield performance. Battle Labs provide a means for the Army's systematical examination of war-fighting ideas and evaluation of the options offered by new technical capabilities (Franks and Ross, 1993).

They went on to say that,

> (T)he objective of each Battle Lab is to determine the potential military value offered by a new capability as early as possible. Products of these efforts typically are software models or early stage 'austere prototypes' such as 'breadboards' or 'brassboards' without the full functionality of complete fieldable systems or components. Testing is likely informal and may involve an iterative model-fix-model or test-fix-test cycle.

This means of virtual prototyping not only facilitates concurrent engineering but also encourages continuous, comprehensive evaluation by the combat development, material development, and test and evaluation communities at the beginning of the acquisition process—when the weapon system is being designed to reduce the time and cost of the acquisition cycle (Ross, 1993; Singley, 1993).

In summary, the PM must develop test bed tools and integrate his efforts with the Battle Labs if he is to demonstrate system capabilities that are not only measurable, but also result in the high fidelity simulations that will streamline the acquisition process. Battle Labs, the Louisiana Maneuvers (LAM), and the methodology of DIS combine nicely to point the way, but the proof is in the implementation. Problems encountered in implementing the concept and methodologies of simulation frequently involve the misperceptions of decision makers. Among these is the widely shared misperception that

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testing must deliver sensational, 'crash and burn' results to be deemed effective by the public. This erroneous expectation must give way to a desire for the in-depth, structured testing and analyses performed in a test bed and Battle Lab environment. That new environment truly provides the qualitative and quantitative data about a weapon system's added value that will support program and system decisions.

Another misperception lies within the systems engineering process. Although the steps in the process are good, how and when these steps are executed is not unalterable, and the perception that they are is mistaken. This is pivotal to the success of Battle Labs.

To implement simulation properly requires a teaming of the user (or combat developer) and the Project Manager (or material developer). The aim of their combined efforts reflects a concurrent engineering philosophy that provides direct feedback into the weapon system development cycle. The goal is to use modeling and simulation to test, evaluate, and further amplify any number of factors in that cycle. Among these: Operational Requirement Document (ORD) requirements, smart technology insertion, comparison of alternative evolutionary concepts, predictions of the system's functional and operational performance, design and development of new devices and algorithms, system integration, system software support, command and control, best doctrinal way to fight the system, and MANPRINT issues. These assessment and development needs are not new; however, that they are obtained as a joint team effort is new.

The Battle Labs concept, with specified centers controlled by the combat developer, is well-understood. Unfortunately, the contribution of the test bed to the Project Manager's team is less visible, as is the interplay of test bed data used by combat developers and material developers. Nevertheless, a fusion of the test beds and battle labs, providing end-to-end simulations and simulators, would foster rapid prototyping through 'hardware-in-the-loop' (HWIL). It would also combine, in a DIS synthetic environment, the domains of research, development and acquisition (RD&A), military operations, and training (see Figure 1).

...the widely-shared misperception that testing must deliver sensational, 'crash and burn' results...

Project managers own the detailed simulations (or test beds) that provide accurate weapon system performance data to wargaming models. These complex test beds place soldiers in detailed simulations of hardware prototypes and new system software to assess the weapon's warfighting 'value added.' Through DIS, test beds enable a new weapon system, or a new configuration of an old weapon system, to interact in a war game in real time. The combat developer is given access to the simulation at his home station. This is the Battle Lab concept enabled through a teaming of users, PMs, contractors, and developers.

Whether test beds support the required evaluation areas and address the widest scope of issues (while remain-

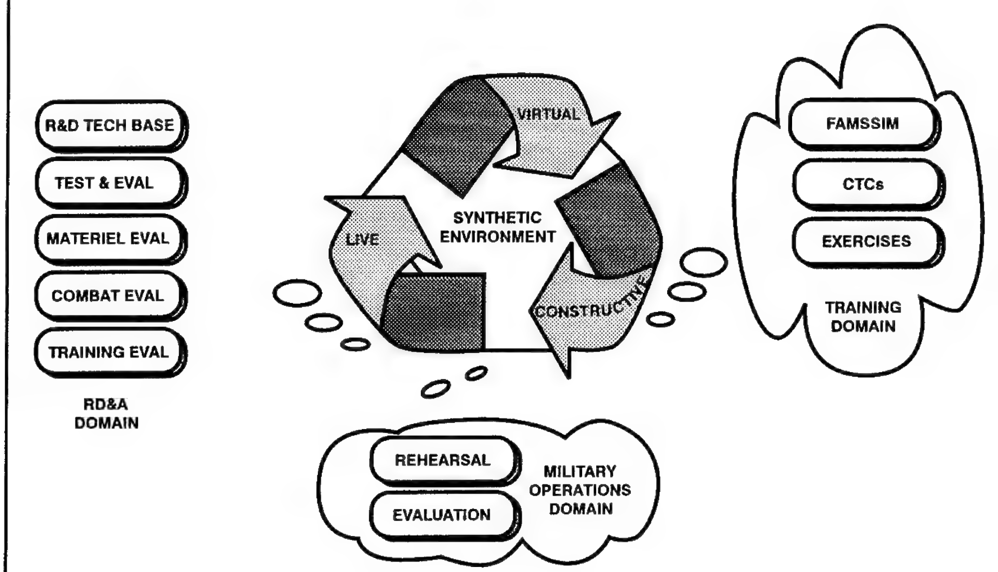

Figure 1. DIS Synthetic Environment

ing flexible and comparatively inexpensive) should be asked in determining exactly what types and combinations of simulations, test beds, and tests are needed. This evaluation is illustrated in Figures 2 and 3.

Evaluation Areas

The next step is to assess whether the detail and scope of the evaluation methodology will support technical requirements generation and evaluation, operational requirements, and overall requirements (e.g., force modernization). The assessment of these applications is shown in Figure 4, as applied to the STINGER/AVENGER, the Forward Area Air Defense (FAAD) Project Office, and the Weapon System Management Directorate (WSMD). Next we assess the scope and detail of the tools [missile simulation (HWIL); weapon system fire unit simulation (HWIL); Software in the Loop, (or SWIL); and Man in the Loop, (or MIL), and the battlefield models], and how these tools interact with each other within the DIS virtual network. This is illustrated in Figure 5 as an integrated evaluation and Test Evaluation Master Plan (TEMP) asset.

ANALYSIS CHARACTERISTICS	EVALUATION METHODS		
	SIM	TEST	ANAL.
SCOPE (RANGE OF ISSUES)	WIDE	MED	WIDE
EXPECTED COSTS	MED	HIGH	LO
FLEXIBILITY	HIGH	LO	MED
FIDELITY	MED	HIGH	LO
CONTROLABILITY	HIGH	LO	HIGH
IMPACT	HIGH	HIGH	LO

BEST GOOD POOR

Figure 2. System Evaluation Methodology Trade-Off

		SYS. ARCH. TRADES	COMPONENT DESIGN	COMPONENT EVAL.	SYSTEM INTEG.	SYS. EVAL. (PA)
SIMULATION	TEST BED	X	X	X	X	X
SIMULATION	ENG. MODELS (EX. - MSL. 6-DOF)		X	X		
SIMULATION	ENGAGEMENT SIM. (BEWSS)	X	X	X		X
TEST	BENCH TESTS			X		
TEST	SYS. ENG. TESTS (DEM / VAL)			X	X	
TEST	OPERATIONAL				X	X

LEGEND:

SYS - SYSTEM
ARCH - ARCHITECTURE
EVAL - EVALUATION
INTEG - INTEGRATION
PA - PERFORMANCE
EX - EXAMPLE
MSL - MISSILE
DOF - DEGREE OF FREEDOM
SIM - SIMULATION
DEM - DEMONSTRATION
VAL - VALUATION

Figure 3. Evaluation Areas

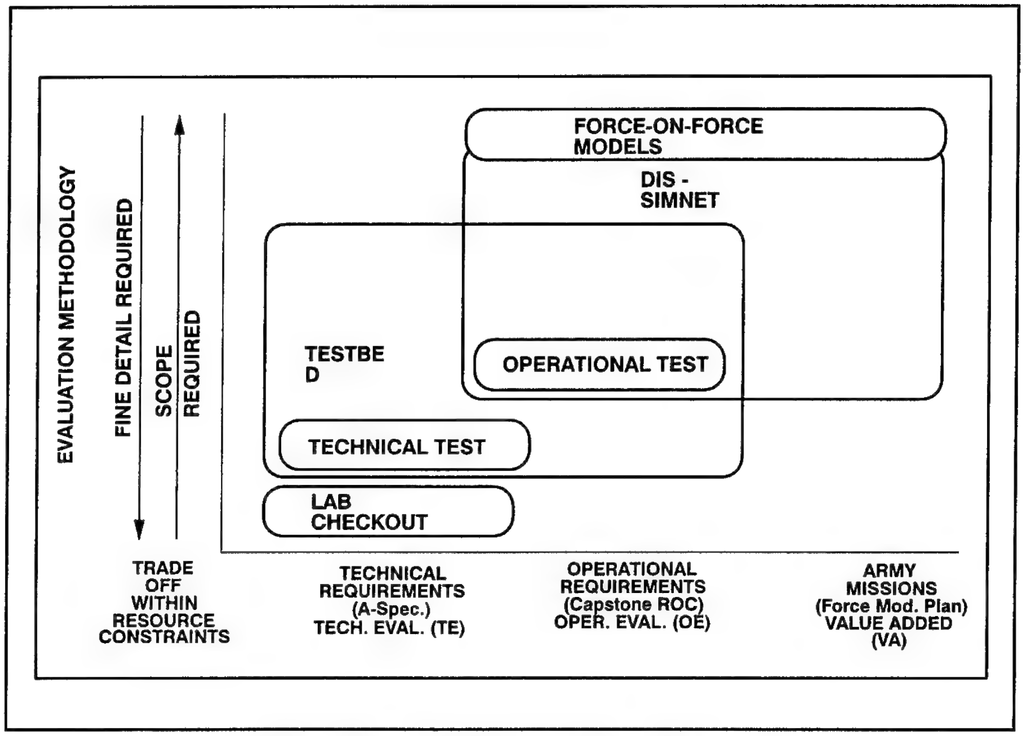

Figure 4. FAADS Simulation Test Bed, System Evaluation Methodologies/Applications

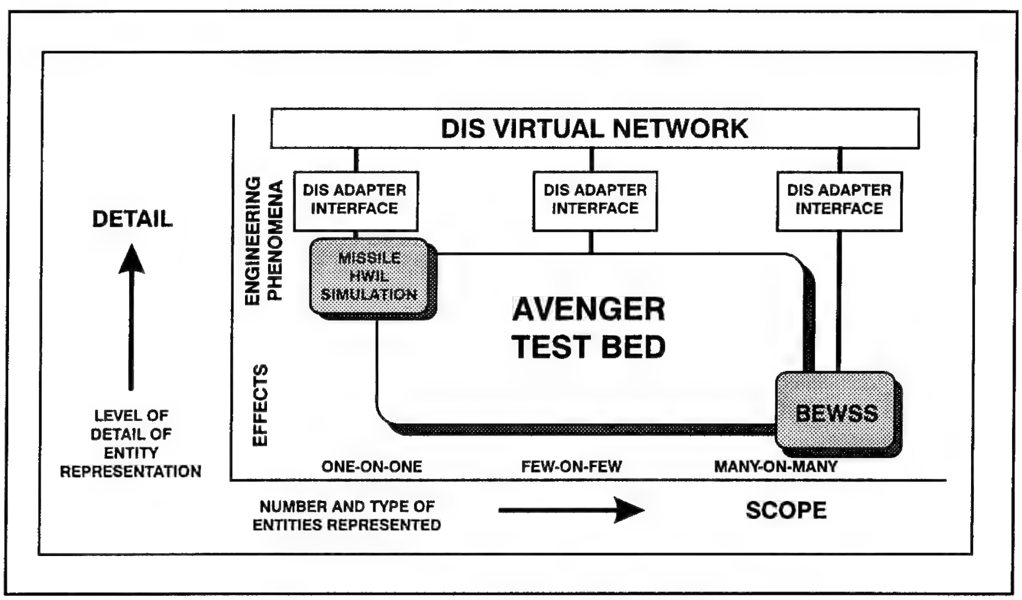

Figure 5. Scope, Detail, and Interaction

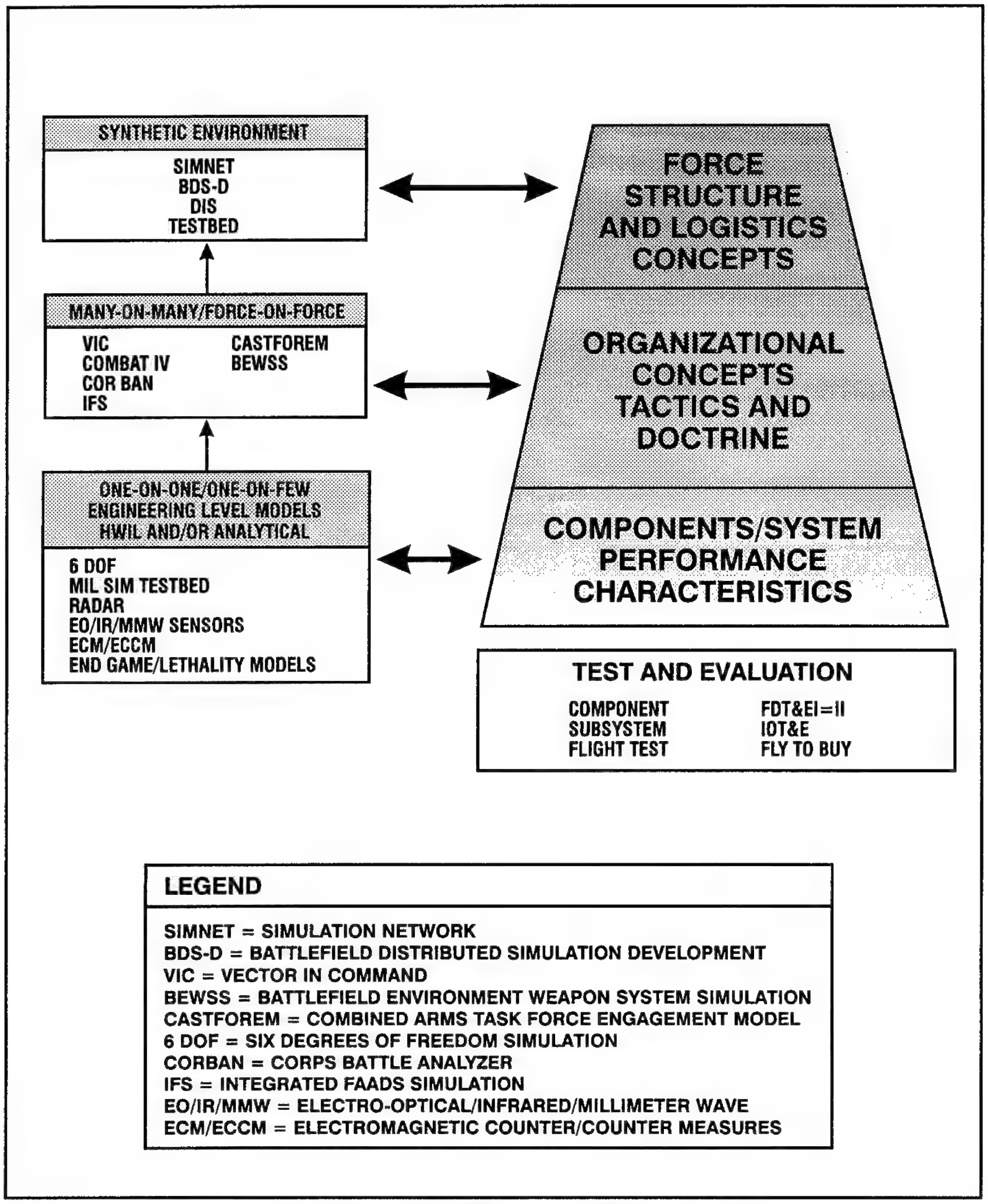

Figure 6. Simulation Hierarchy (PM's Tool Kit)

After determining the detail and scope required of the test bed, simulations and models, an ordering by type and function needs to be performed to produce a simulation hierarchy. This type of hierarchy is shown in Figure 6 for the FAAD PM and WSMD. The next assessment determines how and when the various tools will be needed, and how they should connect (see Fig-

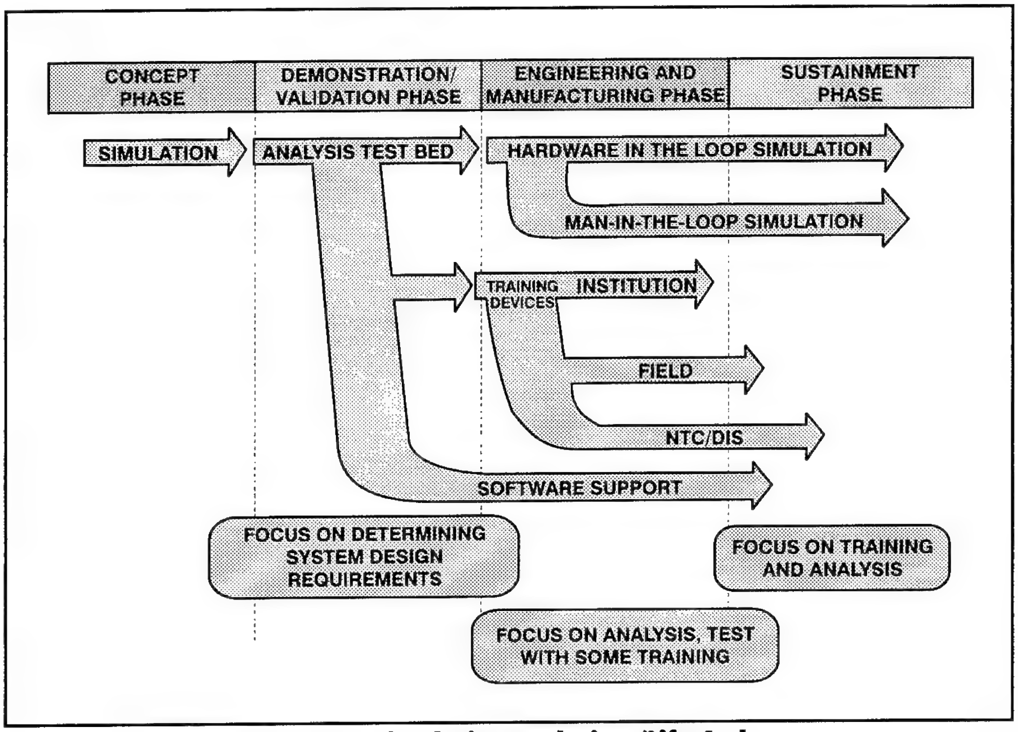

Figure 7. Simulation Evolution/Life Cycle

ure 7). Within this evolution, the simulated weapon system prototypes are evaluated by soldiers. This process of virtual prototyping produces the benefits seen in Figure 8.

The Air Defense Program Executive Officer (PEO) completed an initial review of the library of battlefield models in 1989. He concluded that no existing model could provide all of the features needed and desired for analyses of Forward Area Air Defense (FAAD) systems. Instead, it would be necessary to use several models in support of system performance assessments, tactics, and doctrine analyses. The survey identified minimum requirements for models and defined criteria for evaluating and comparing models. A subsequent evaluation of each model's applicability and utility for analyzing FAAD issues was also conducted. This revealed that the models would have to be capable of supporting battalion-sized or larger units in an asymmetric play of forces (e.g., Blue tactics by Blue, Red tactics by Red). The models would also have to be in use at present in the simulation community.

The CASTFOREM, JANUS(T), and VIC models were chosen; together, the three models satisfied the battlefield integration issues. Many of the detailed outputs from the interactive JANUS(T) could be fed into CASTFOREM. Similarly, some of the battalion and brigade-level results from

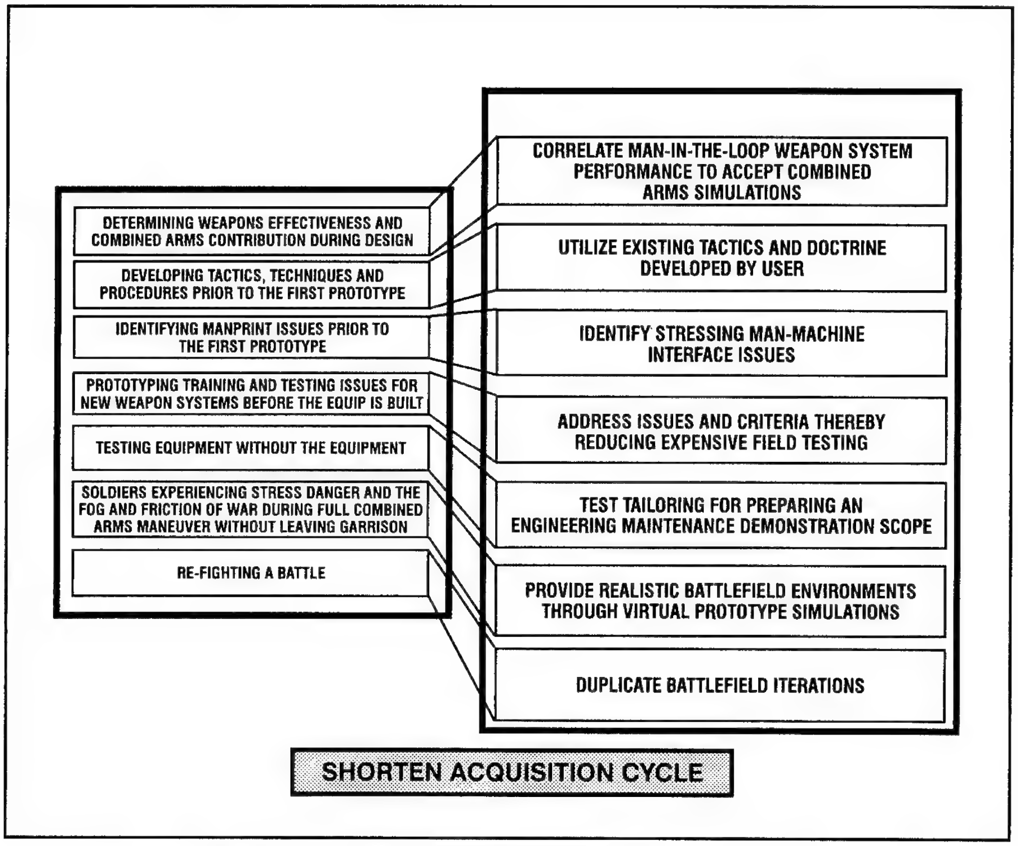

Figure 8. Virtual Prototype Simulation - Life Cycle

CASTFOREM could be used as input for the corps and division-level VIC simulation (Air Defense PEO, 1989). Yet all three had major drawbacks: They assumed perfect identification of friend or foe (IFF); they modeled command and control logic through decision tables only, thus not allowing for assessment of a C3I capability on the battlefield; they lacked detail in the play of fixed-wing aircraft; they excluded fratricide; they allowed no explicit electronic warfare play; and they used unchanging weather parameters. In addition, JANUS(T) provided only a very coarse level of modeling for a fire unit by assuming perfect targeting by the threat (Red) aircraft, an 'a priori' knowledge of Blue's location by Red aircraft, and visual identification ranges for Blue forces applicable to tanks rather than the detection, recognition, and identification ranges common to sensors in Air Defense units. Nevertheless, these limitations of the models make a test bed attractive since their outputs, when inserted into the VIC battle, can easily provide the correct inputs for a CASTFOREM or VIC model, or any upgrade of these with higher resolution and fidelity.

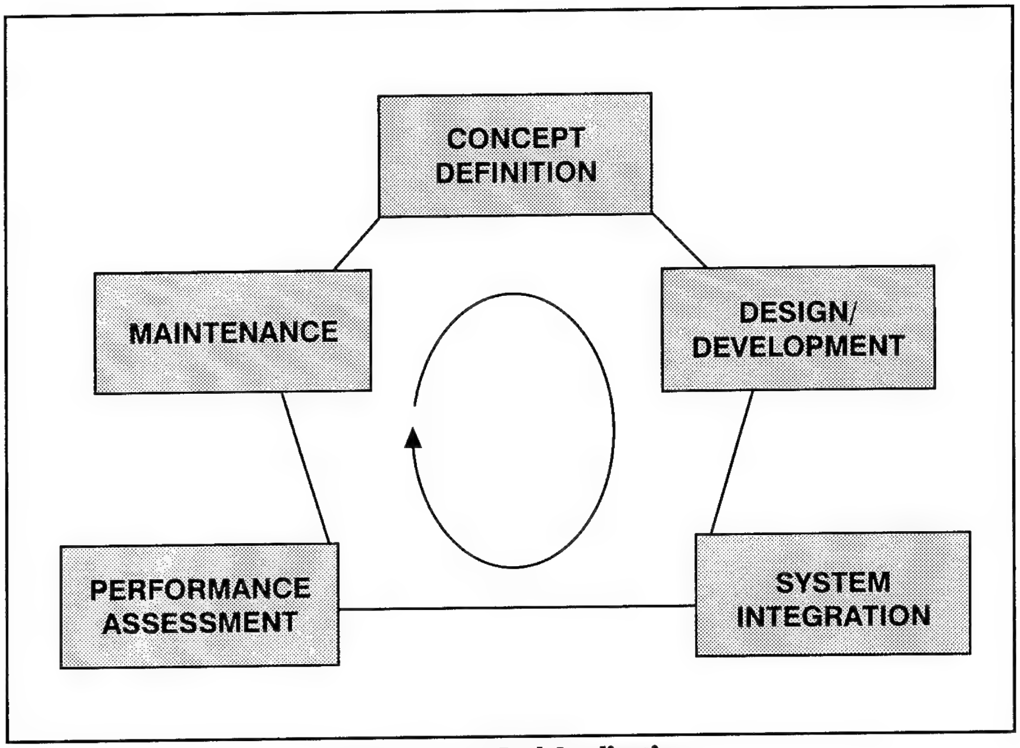

Figure 9. Test Bed Applications

The Utility Of Implementation

Within the constraints of the preceding section, the test bed is an analysis tool emulating the weapon system and used to conduct experiments, studies and analyses to support: a) predictions of the system's functional and operational performance; b) comparison of alternative evolutionary concepts; c) design and development of new concepts, devices and algorithms; d) system integration; and e) maintenance and support of system software (AVENGER Project Office, 1992) (see Figure 9).

A wide variety of concept and configuration trades-offs are necessary in any system's evolutionary development. This use of test beds is manifested at several levels. At one level, the test bed allows investigation into alternative structures for weapon systems or relationships between system components (e.g., the effects of system modularization, element intercommunication, and centralization of decision making). Another level of test bed use is the selection of alternative weapon system elements (i.e., technology insertion) based on comparisons of their effectiveness. A third level of test bed utility lies in measuring variations in a significant component's characteristics and how they impact the effectiveness of the full system. These three levels of analyses provide the basis for informed decisions on trade-offs.

Test beds also support component design and development. The test bed is used to shake down preliminary designs (i.e., analytical models), evaluating them in the context of weapon system objects and functions. This enables the subsystem to be studied in a controlled but realistic operational environment for which the design variables serve as study parameters. It also allows other elements of the system to influence modification and evaluation of the design, as well as permitting observation of the effects of design parameters on system performance.

Design and development of components and subsystems are brought together in system integration. The test bed has tremendous utility for reducing the high risk in this area. System integration issues explored on the test bed include functional or operational coordination, completeness, and integrity; system interface validation; data fusion; and the cooperative operation of system elements. The test bed may also serve to identify and quantify any problems in functional or data interface and to investigate alternative solutions for such problems, and also serve to support experiments or demonstrations of system integration concepts.

Performance assessment of a weapon system is another use of the test bed, as is validation of engagement simulations or wargaming models. The test bed can generate data invaluable in validating engagement models by demonstrating the system's fully integrated operational functions under full engagement scenarios. Using the test bed to predict the results of a weapon system's field and firing tests supports pre-test planning and post-test analyses, reduces the amount of real world testing required, saves time and money, and provides results that are more constructive and defensible.

In today's software driven weapon systems, the test bed is a necessary complement to the normal software development environment. The test bed provides the complex and realistic stimuli and operational states necessary to determine the adequacy of the weapon system's operational, imbedded software.

Summary

The Test Bed and Tools for DIS are ready and functional. Integration and consolidation of efforts to utilize these tools must be continued. Many resources and simulations are untapped that can help the Project Managers and the user. The Program Executive Officer and TRADOC User communities need to synchronize their efforts to create cost effective weapons systems and system improvements through robust simulations.

REFERENCES

Air Defense Program Executive Officer (PEO). (1989). Appendix A: Simulation Model Survey. *Forward Area Air Defense System Simulation Plan*, (Report MA89-PEO-AD-0001), Feb. 17. Author.

AVENGER Project Office. (1992). *System Specification for the AVENGER Simulation Test Bed (Draft)*, July. Author.

Franks, Gen. F.M., Jr. and Ross, Gen. J.D. (1993). *How To Do Business With Battle Labs - A Guide For Industry*. Washington: Army Materiel Command.

Ross, Gen. J.D. (1993). Legacy for '90s in Louisiana Maneuvers. *Army*, June.

Roos, J.G. (1992). An Exclusive AFJI Interview With: General Frederick M. Franks, Jr., USA, Commanding General, US Army Training & Doctrine Command (TRADOC). *Armed Forces Journal International*, October.

Singley III, G.T. (1993). Distributed Interactive Simulation-A Preview. *Army Research, Development and Acquisition Bulletin*, March-April.

Slear, T. (1992). Battle Labs: Maintaining the Edge. *National Defense*, November.

BATTLE LABS: WHAT ARE THEY, WHERE ARE THEY GOING?

John R. Wilson, Jr.

Battle Labs serve as a mechanism for assessing ideas and capabilities provided by advanced technology. More than this, however, Battle Labs represent a revolution in global thinking, testing by computer simulation, and streamlined acquisition. This paper explains what Battle Labs are and what they will be used for, now and in the future.

The Army's leadership initiated the Louisiana Maneuvers and the TRADOC Battle Labs to reshape the service for the post-Cold War era (Singley, 1993) (see Figure 1).

The Louisiana Maneuvers (LAM) are used to study battlefield capabilities and other preparedness issues using a mix of real and simulated forces. The Army leadership use the LAM to make decisions about doctrine, force mix, force composition, and other areas involving fundamental change (Ross, 1993). They are also used to evaluate the Army's ability to provide ready forces in a timely manner to meet several force-projection scenarios (Goodman, 1992). The LAM use advanced simulation technologies to enable remote units to participate in war games and test all phases of Army operations (Goodman, 1992). Advanced simulation technology is the key to the LAM's success in helping the Army leadership visualize and understand the impact of evolving equipment and doctrinal changes on battlefield performance (Ross, 1993). Simulations also avoid putting large numbers of troops in the field to train battle staffs and test new doctrine, plans, equipment, and ideas. The LAM serve as an Army process and tool, supported by TRADOC Battle Labs, and focused on warfighting modernization and policy making (Singley, 1993).

In reshaping itself into a smaller, contingency-oriented, power projection force, the Army's imperative is to maintain its technological superiority (Franks and Ross, 1993). The TRADOC Battle Labs play a part in

this reshaping process and provide a means for streamlining the materiel acquisition process.

The Battle Labs serve as a mechanism for assessing ideas and capabilities evolving from advanced technology (Franks and Ross, 1993). Rather than a single place or set of resources, Battle Labs represent a harnessing of brain power committed to preparing the Army for the next war (Slear, 1992). The objective of each Battle Lab is to determine the potential military value offered by any new, 'leap-ahead' technology early in the acquisition process. The Army focuses on six specific battlefield dynamics and each is represented by a Battle Lab electronically linked to its counterparts, allowing the Army to cross any functional lines and tap into emerging technologies (Slear, 1992).

A Revolution in Thinking

The Battle Labs concept (Figure 2) is a revolution in global thinking, test by computer simulation, and streamlined acquisition (Slear, 1992). Battle Labs are a new way of doing business (Franks, 1993) and will institutionalize a new way of thinking–a 'paradigm shift'–guided by cooperation and integration (Slear, 1992). They will serve as focal points for examining the impact of the latest battlefield organization, tactics, doctrine, and technological capabilities on the battlefield of the future (Franks and Ross, 1993).

The simulation capability harnessed through the Battle Labs is evolving into virtual reality (Slear, 1992). The Battle Labs allow the Army to evaluate the battlefield performance of new technology by using simulations or prototypes (Roos, 1992). This is accomplished via a network of computer simulations connecting the six Battle Labs, known as Distributed Interactive Simulation (DIS), which serves as the foundation for the LAM exercises. These simulations generally fall into one of three categories: live, constructive, or virtual (Ross, 1993).

Live simulations include those exercises conducted by soldiers on field exercises. Constructive simulations are computerized wargaming models with the battlefield in the computer. They use programmed input to 'fight' battles on computers with models which are interactive and put soldiers in the loop to react to battlefield situations. Virtual simulations are trainers such as flight simulators or tank simulators that create a realistic synthetic environment to train and test soldiers.

Simulations from the Battle Labs represent reality in a highly believable way, whether simulating theaters of war or factories and their manufacturing processes (Franks and Ross, 1993). The

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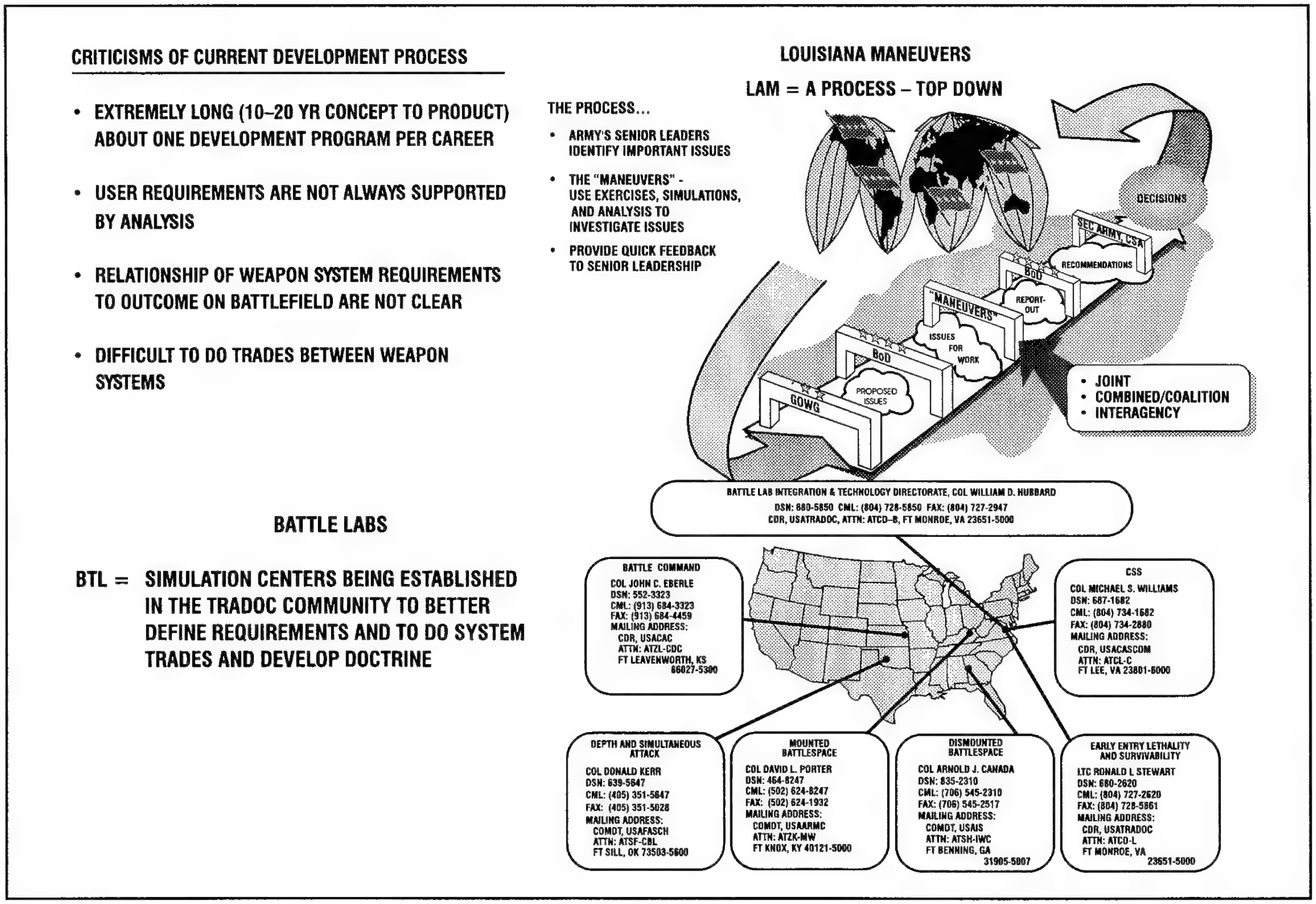

Figure 1. Battle Labs (BTL)/Louisiana Maneuvers (LAM) (Changing the Process)

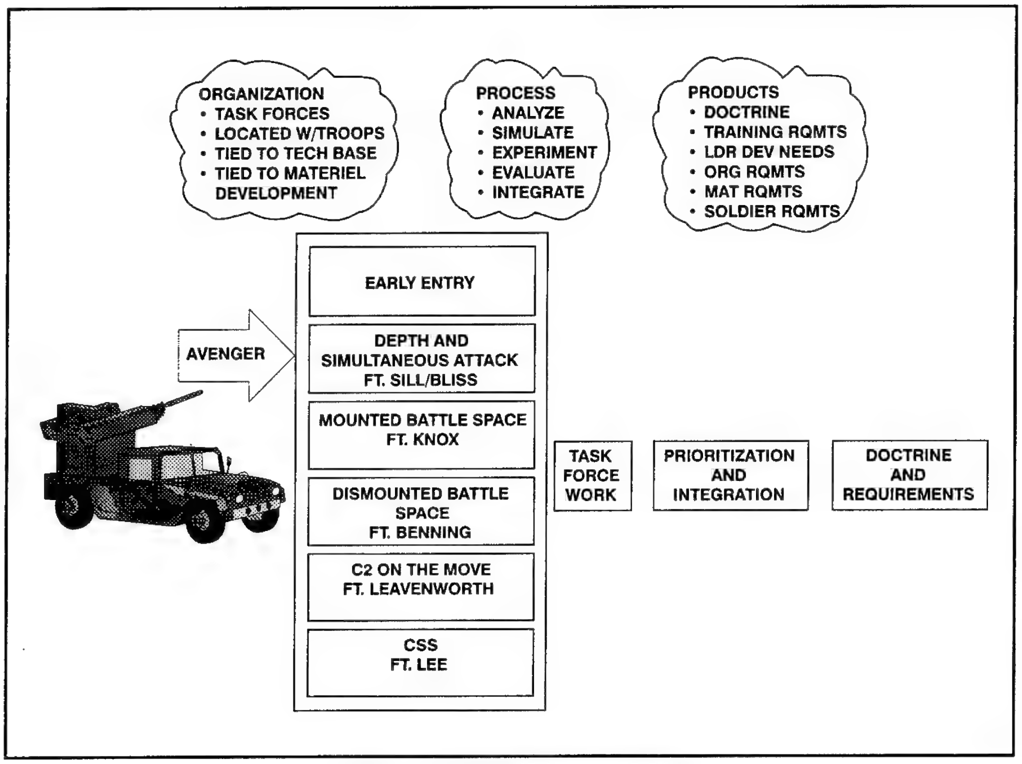

Figure 2. Battle Lab Concept

DIS transmits situational awareness data to maneuver units and the Battle Labs (Franks, 1993) and creates a synthetic, virtual representation of the battlefield by connecting the separate simulations from multiple locations over the Defense Simulation Internet (DSI). This connection of simulations forms a 'seamless integration' (Lang, 1992).

The Army uses this synthetic environment to test and evaluate the impact on overall battlefield performance of new and existing weapon systems, technology insertions into existing weapon systems, or the tactical deployment and logistical support of weapon systems (Ross, 1993). The DIS allows for the practice of warfighting skills and the evaluation of weapon system performance when cost, safety, environmental, or political constraints prohibit actual field tests and training (Ross, 1993).

As General Gordon R. Sullivan, Army Chief of Staff, recently stated:

> The most promising technologies will be tested by real soldiers, first in reconfigurable crew stations, then in full-scale simulators. Final designs, production, and assembly steps are also simulated in virtual factories before actual prototypes are made. Then the actual and virtual prototypes are exercised si-

multaneously to discover potential problems before production begins (Binder, 1993).

Gen. Sullivan also stated:

(T)here is a great deal of frustration with the cold war acquisition system. It served us well, but it is inappropriate to the current threat environment, technology, and resource environments. It is very much a linear system—a system of discrete little boxes—and what we require now is a nonlinear system, a system with connectivity, not boxes. The Army must change to survive and grow. The technological possibilities are immense and could become overwhelming without a mechanism that allows us to assess the possibilities and control the pace of change. That mechanism is the Louisiana Maneuvers (Binder, 1993).

Streamlining the System

A look at the current status of our weapon systems and the acquisition process that generates them shows that we now have very complex, software-driven weapons systems, many of which still do not meet requirements after 10 years of concept definition and development. This condition was recently restated by a Department of Defense (DoD) study group investigating problems in testing (Under Secretary of Defense, 1994). The primary findings were:

1. The requirements generation and management process led to unrealistic operational requirements.

2. Program Development Testing and Evaluation (DT&E) was not sufficiently robust to confidently enter Operational Testing and Evaluation (OT&E) phase of testing.

3. System boundaries were not sufficiently defined.

Several contradictions in our current acquisition process are made apparent in the summary in Figure 3. Our weapons systems are very complex, yet we insist on low bid solutions. This can be the 'sting of death' for a program: Inexpensive but inexperienced contractors may prove unable to meet our engineering development requirements due to their lack of expertise or their underestimation of the effort necessary; alternatively, the program may amass overruns trying to overcome a more sophisticated contractor's lowball, 'buy-in' proposal.

Our acquisition system is not designed to succeed by encouraging innovative flexibility; perhaps that is why there are so few acquisition success stories in the 1990s. Another factor: rapidly changing doctrine that outpaces the acquisition processes. Is it any wonder that the Army's leadership is seeking a 'paradigm shift' when we read that soldiers are denied the improved systems they want and are forced to accept other systems they neither want nor need?

- WEAPON SYSTEMS ARE COMPLEX
- DIGITAL SYSTEMS HEART OF NEW SYSTEMS
- MOST NEW SYSTEMS ARE DELIVERED LATE
- MOST NEW SYSTEMS ARE COSTLY (COST OVERRUNS)
- MOST NEW SYSTEMS HAVE PERFORMANCE SHORTFALLS
- MOST NEW SYSTEMS ARE EXPENSIVE TO MAINTAIN
- MOST NEW SYSTEMS ARE REQUIREMENT DEMANDING
- MOST PROGRAMS SUFFER FROM TIGHT BUDGETS
- LOW BID ATTEMPT TO SOLVE COMPLEX TECHNOLOGY
  SOFTWARE - ACHILLES HEEL OF WEAPON SYSTEMS

Figure 3. Current U.S. Systems' Status

Software is the critical path of system development, and system performance depends on it. It has become the 'Achilles Heel' of weapons development (Kitfield, 1989). Figure 4 reflects the immense, rapidly increasing market cost of DoD software as compared to the relatively flat cost projections for computer hardware (Defense Systems Management College, Unk.). Why doesn't DoD control this cost? The answer is easy: DoD represents only 15 percent of the total market for software (see Figure 5) (Huskins, 1994). It is, overwhelmingly, a civilian market not amenable to regulation by DoD.

The Army estimates that 65 percent of the money it supposedly spends on software is actually paid to define system requirements (Kitfield, 1989). The state-of-the-art technology driving these requirements at the beginning of development is often obsolete before the system is fielded (Defense Systems Management College, Unk.), a fact rarely considered in awarding contracts to a low bidder already at his technical limits. Moreover, a program manager that spends precious dollars on software tools and reusable software racks up an increased cost that may put his program at risk. This low bid mindset also ignores the peculiarities of the software market, where the product is strictly conceptual and the means to realize it are largely intellectual (Kitfield, 1989).

As support for the Battle Labs — from the grass roots as well as from the leadership—has made obvious, the

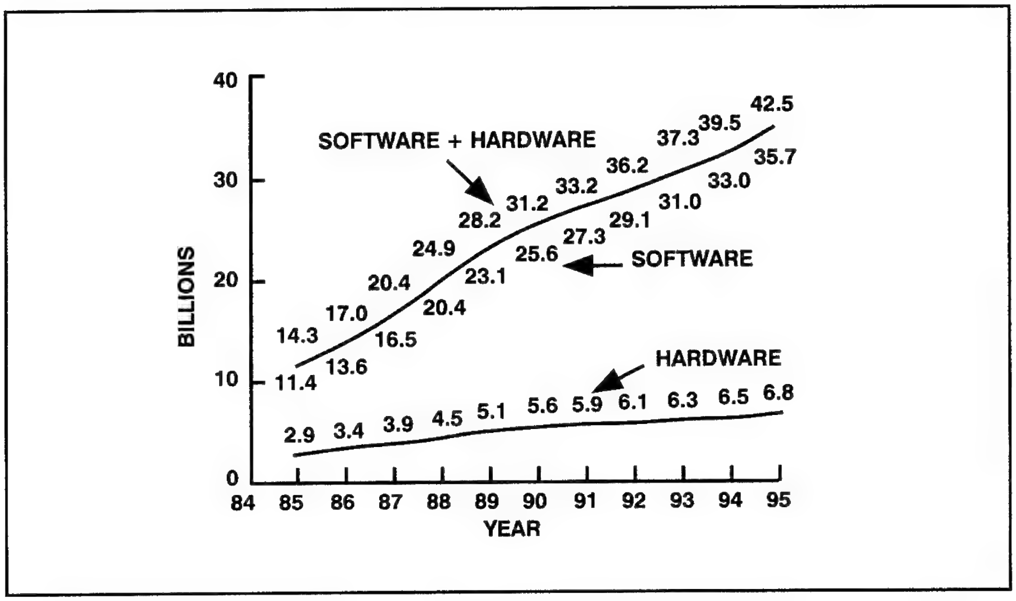

Figure 4.

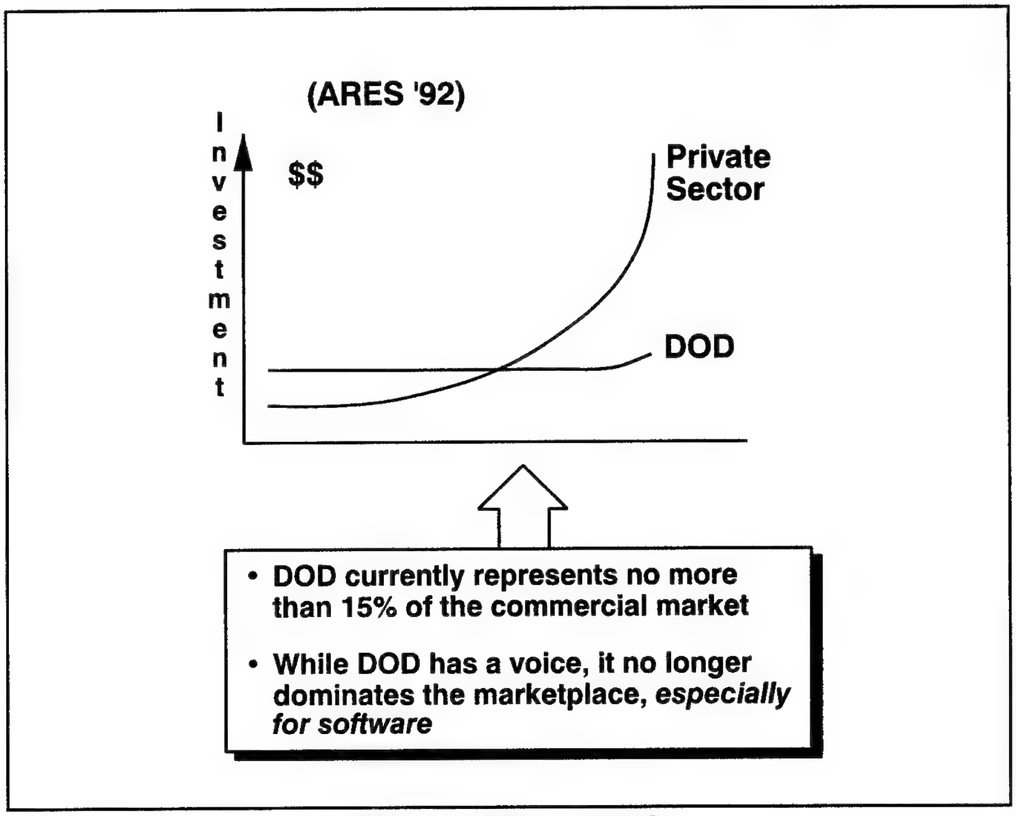

Figure 5. Relevant Trends

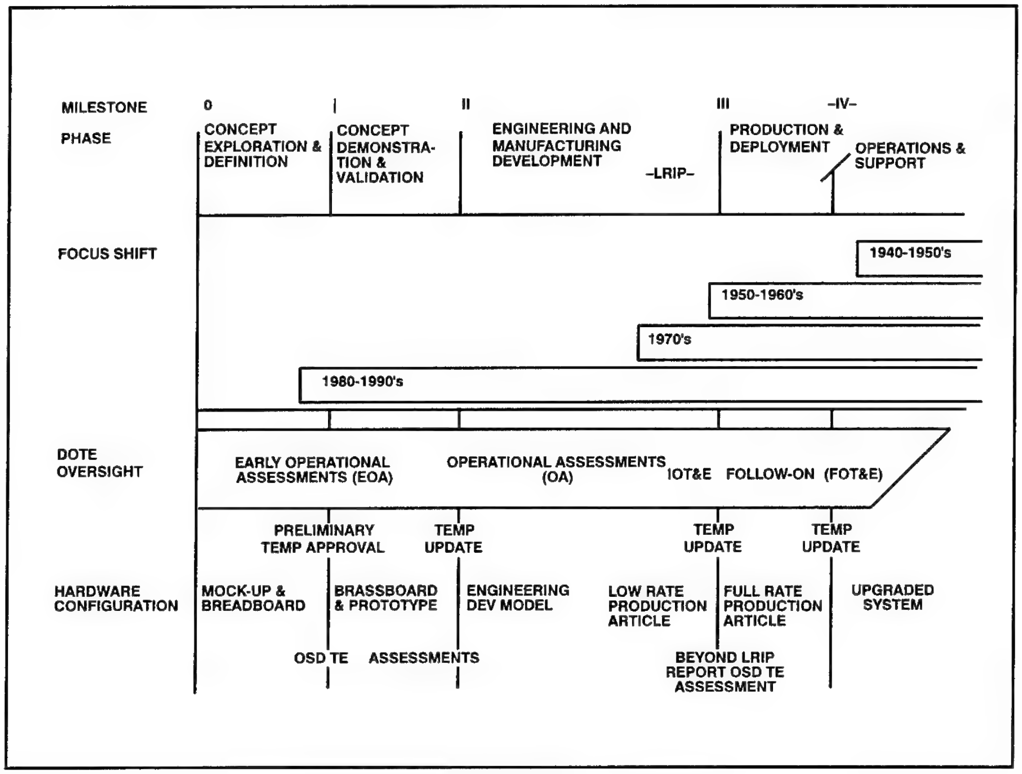

Figure 6. Changing Focus on ODT&E

need for concurrent engineering is now apparent and has started to dismantle the walls of compartmentalization. The focus on the testing and tester involvement in development is changing as shown in Figure 6 (Franks, 1993). The acceptance of testing and evaluations conducted in a virtual environment, on a synthetic battlefield, will lead to significant savings as much of the current field testing is eliminated (Ross, 1993). The realization that software, not hardware, is the driver is embodied in the Battle Lab philosophy of making engineering development and test possible earlier on (well into concept development and definition), as well as getting everybody involved through development teaming. Success in reshaping the Army requires that only the most cost-effective advanced technologies (i.e., those most likely to be found in software) are pursued to ensure a technological edge. Along with technology, the cycle time from laboratory to prototype and production must be reduced; otherwise, the advantage of developing a leading edge technology is lost (Franks and Ross, 1993). Taken together, these points reflect an understanding that early expenditures provide the greatest leverage in preventing errors. Up to 70 percent of errors are detected early, when error correction is cheapest (MaCabe and Schulmeyer, 1987).

Typically, almost 90 percent of a

weapon system's cost is decided before entering development (Figure A of Figure 7); it would be a mistake wait for errors in the decision-making process to appear in the costly operational test, production, and deployment phases (Singley, 1993). We are, nevertheless, failing to detect errors before making decisions affecting what will amount to 60 percent of the costs for our weapon systems throughout their life cycles (Figure C of Figure 7).

As Gen. Sullivan has stated:

> (T)he new focus is that we are pushing armor, infantry, the entire combined arms team into the digitized world where most weapon improvements are through software revisions. While the core of the 20th century land warfare is the tank, the core of the 21st century is the computer. Simulations are used to maintain readiness in a military force in which downsizing and tight budgets are prime considerations for the foreseeable future (Binder, 1993).

The way is identified and the pressures are great (Figure 8). What is needed are the 'paradigm pioneers' to lay the road.

The use of Battle Labs is a needed change to keep pace in this rapidly developing information age, but to suc-

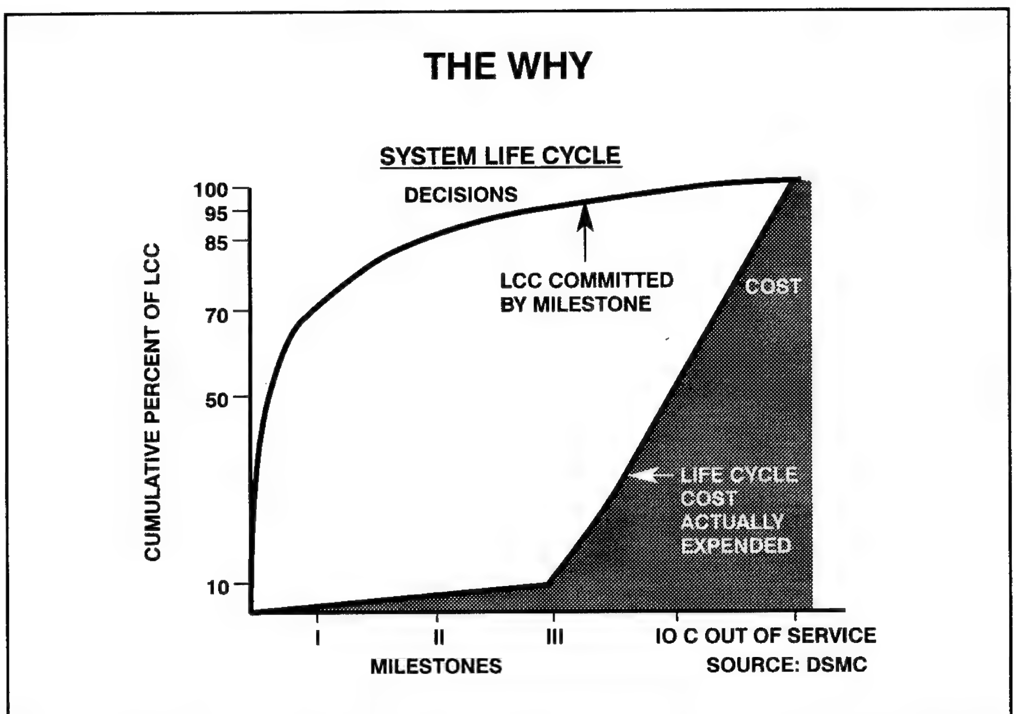

Figure 7-A. The Why - Typical System Life Cycle Cost Commitment

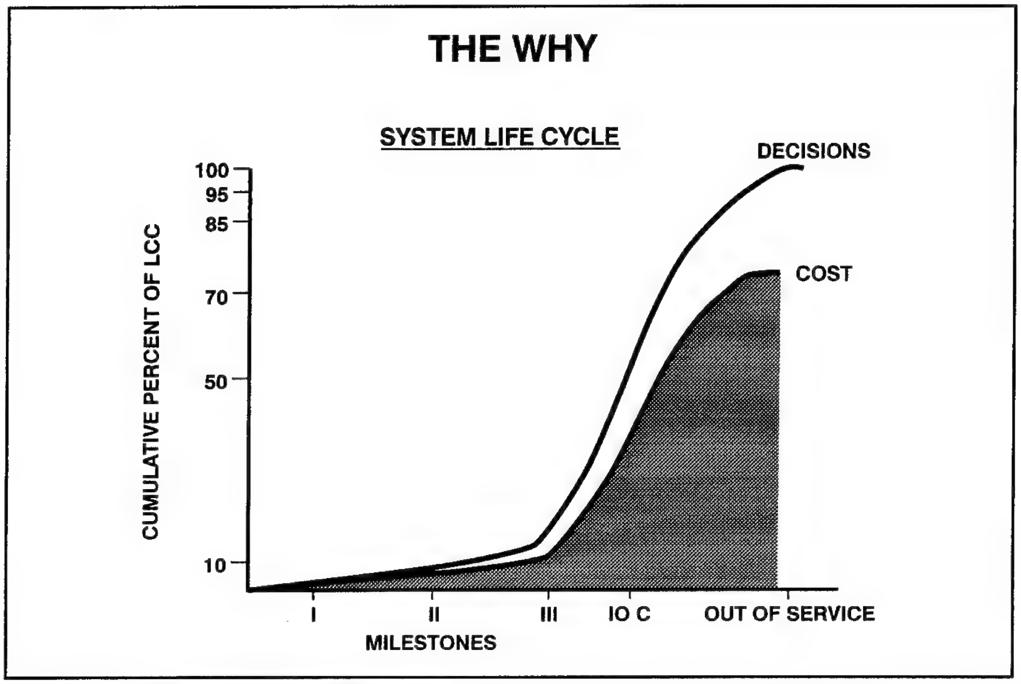

Figure 7-B. The Why - NDI System Life Cycle Cost Commitment

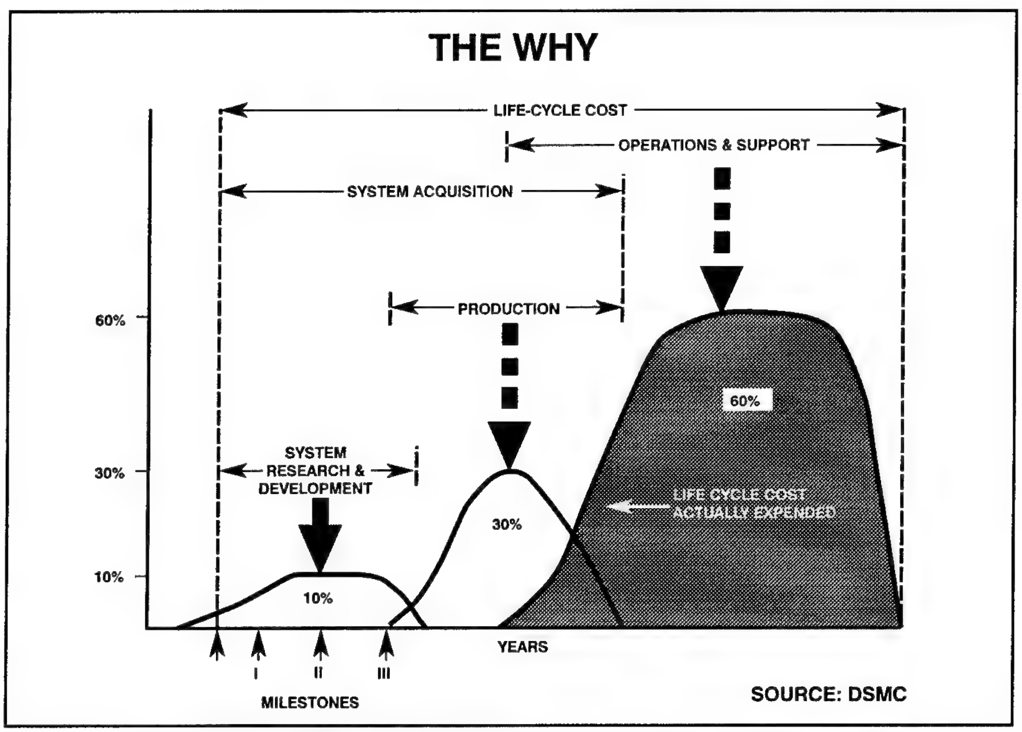

Figure 7-C. The Why - Typical System Life Cycle Cost Distribution

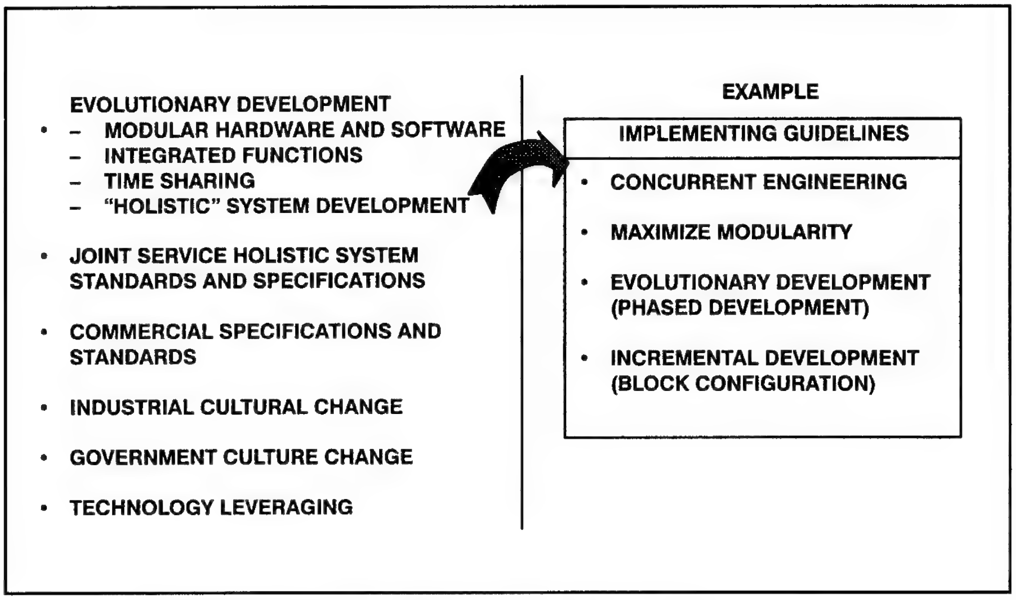

Figure 8. Paradigm Pressures

ceed it will require visionary leadership as well as good management skills. Albeit with growing pains, Battle Labs are here to stay.

References

Binder, James L. (1993). Welcome to the 21st Century. *Army*, July.

Claxton, J. (1994). TE 633 - Program Management Course. Fort Belvoir, VA.: Defense Systems Management College.

Defense Systems Management College. *Mission Critical Computer Resources Guide*. Fort Belvoir, VA: Author.

Franks Jr., Gen. F.M. (1993). The Battle Lab Method. Presented at *AUSA Winter Symposium*, February. Washington: Author.

Franks Jr., Gen. F.M. and Ross, Gen. J.D. (1993). *How To Do Business With Battle Labs - A Guide For Industry*, June. Washington: Authors.

Goodman Jr., G.W. (1992). Maneuvers to Test Force-Projection Army. *Armed Forces Journal International*, October.

Huskins, LTC J. (1994). SM 657-Program Management Course. Fort Belvoir, VA: Defense Systems Management College.

Kitfield, J. (1989). Is Software DoD's Achilles' Heel? *Military Forum*, July.

Lang, W.N. (1992). The Revolution Represented by The DMSO. *National Defense*, November.

MaCabe, T. J. and Schulmeyer, G. G. (1987). The Pareto Principle Applied to Software Quality Assurance. In *Handbook of Software Quality Assurance*, G. Gordon Schulmeyer and James I. McManus (eds.). New York, NY: Van Norstrand Reinhold Company Inc.

Roos, J.G. (1992). An Exclusive AFJI Interview With: General Frederick M. Franks, Jr., USA, Commanding General, US Army Training & Doctrine Command (TRADOC). *Armed Forces Journal International*, October.

Ross, Gen. J.D. (1993). Legacy for '90s in Louisiana Maneuvers. *Army*, June.

Singley III, G.T. (1993). Distributed Interactive Simulation - A Preview. *Army Research, Development and Acquisition Bulletin*, March-April.

Slear, T. (1992). Battle Labs: Maintaining the Edge. *National Defense*, November.

Under Secretary of Defense (Acquisition & Technology). (1994). *Study Group Report on Evaluation of Electronic Systems Acquisition*, February. Washington: Author.

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